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Effects of Three Leaf Shape Genotypes of Gossypium Hirsutum L. And Row Types on Plant Microclimate, Boll Weevil Survival, Boll Rot and Important Agronomic Characters.

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ABSTRACT

Tests were conducted for three years at Baton Rouge and St. Joseph, La., with three leaf shape genotypes of upland cotton (*Gossypium hirsutum* L.) in solid and skip-row plantings (row types). The differences among the three leaf shape genotypes, 'Stoneville 7A', La. Okra-2 and La. Super Okra-2 were attributed primarily to differences in leaf area and shape. The latter two strains were developed after six backcrosses to the Stoneville 7A cultivar. Plant microclimate, boll weevil (*Anthonomous grandis* Boh.) survival, boll rot and other important agronomic characters were studied.

Super okra and okra leaf canopies resulted in higher soil surface temperatures, increased sunlight penetration, lower relative humidity values and shorter durations of 95% or higher relative humidity compared to that of normal leaf.

The percent boll weevil survival was also lower under super okra and okra leaf canopies than under normal leaf canopy during hot, dry periods. There was a moderately strong negative correlation between soil surface temperatures and boll weevil survival. Total degree-hours above 85 F during the first week and total degree-hours above 90 F during the second week of exposure, together, were found to be responsible for almost 50% of the variation in boll weevil survival. A linear regression equation was fitted

involving the two temperature variables (independent) on weevil survival (dependent) in order to predict weevil survival rates based on temperature data. During wet periods, leaf shapes either did not affect weevil survival or survival was slightly higher under super okra and okra leaf canopies when compared to normal leaf canopy. However, a more open canopy like that of super okra was found to have some advantage in suppressing the boll weevil population build-up during dry periods by reducing their survival rate. Skip-row planting, tested in one year, did not have any significant advantage over solid planting in this respect.

Skip-row planting resulted in higher boll rot losses (284 lb/acre) than solid planting (222 lb/acre). Super okra and okra leaf shapes caused an overall average reduction of 38.2 and 15.9% in boll rot losses over normal leaf.

Normal leaf cotton yielded significantly higher than okra and super okra leaf cottons, as an average of locations and years. Greater percentage of the crop was harvested at first picking in super okra and okra leaf plots than in normal leaf plots. If the first picking was delayed until approximately 70% of the crop was open, super okra leaf plots could be harvested an average of 5 and 11 days earlier than okra and normal leaf plots, respectively. Row types did not have a significant effect on earliness, though a slightly higher percentage of the crop was harvested at first picking in solid-than skip-row.

Normal and okra leaf cottons had higher average boll weight, lint percentage, 2.5% span length, fiber length uniformity ratio and fiber strength values than super okra. Row types did not have any effect on these characters.

The row type x leaf shape interaction was significant (in the combined analysis) for lint yield only. It indicated that super okra leaf shape could not compensate in yield as well as normal or okra leaf shapes for wider row spacings.

It was concluded that okra and super okra leaf shapes may be of some value in suppressing a build-up of boll weevil population and in reducing boll rot losses. Perhaps, these advantages attributed to okra and super okra leaf shapes may be realised even more under a drier climate than at Baton Rouge.

INTRODUCTION

Boll weevil (*Anthonomous grandis* Boh.) and the boll rot complex rank top in the list of factors limiting cotton (*Gossypium hirsutum* L.) yields and profits in Louisiana and much of the Cotton Belt of the United States. Boll weevil is the key insect pest, particularly in the Mississippi Delta area, requiring the use of intensive chemical control measures. Reportedly, this pest was responsible for more than 40% of the average annual loss attributed to cotton pests during 1951 to 1960 in the United States. This amounted to an estimated loss of 1,239,000 bales valued at $ 200,613,000 (Elliot, Hoover and Porter, 1968). It is estimated that boll rot in Louisiana causes an annual loss of 8 to 12% of the potential production (Pinckard and Chilton, 1966).

It became apparent to early researchers that earliness in cotton was the most effective and immediate way to reduce the damage from boll weevil (Hunter, 1911). Later, weevil control by using organic insecticides was so effective that cultural methods of control or host plant resistance to the weevil were no longer considered essential. But, by the mid 1950's, the long term credibility of insecticides came under close scrutiny as the boll weevil developed resistance to certain chlorinated hydrocarbon insecticides (Roussel and Clower, 1955). The implications for the future are clear. Cotton insects will have to be controlled or managed with techniques that place less emphasis on the use of insecticides (Walker and Niles, 1971).

From the second day after oviposition the cotton squares begin to fall down to the ground and in about 7 to 9 days, a substantial number of squares fall down. The weevil completes its development in the square on the soil surface. During this period, the fallen square and the developing weevil are subjected to the relatively high temperatures of the soil surface. In periods of sustained high soil surface temperatures, appreciable mortality may occur (Fye and Bonham, 1970). This means, the plant microclimate is quite important in the build-up of boll weevil population.

The plant microclimate is largely an influence of weather and density of plant canopy. The normal cotton has a dense canopy and generally provides a shady and relatively cool climate congenial for weevil development. The okra and super okra leaf shapes, because of their deeply cleft, narrowly lobed, and small leaves, have much more open canopies than normal leaf cotton and may be expected to provide a less favorable microclimate for the development of the boll weevil.

Cotton boll rots are caused by several pathogenic and saprophytic fungi and bacteria, such as, Fusarium spp., Diplodia spp., Glomerella gossypii Edg., Pestolatia spp., Pellicularia filamentosa (Pat) Rogers, and Phytophthora spp. (Pinkard and Chilton, 1966).

Ordinarily, boll rots are more prevalent in humid areas of the United States Cotton Belt due to frequent periods of adverse weather during boll opening. But, they do occur in any of the cotton producing states where excessive fertilizers and irrigation produce rank growth which prevents air movement, light penetration, and rapid drying after bolls open.

The microclimate within a more open canopy is known to be less favorable for fungi and bacterial development than within a dense canopy (Newton and Ranney, 1964). Some methods of opening the plant canopy are: bottom defoliation, slot defoliation, topping, skip-row planting, and breeding cottons with open type canopies.

The okra and super okra leaf cottons have much more open type canopies than normal leaf cottons and have been reported to effectively reduce the incidence of boll rot (Andries et al., 1969 and 1970).

Skip-row planting is a cultural method for obtaining higher yields from limited cotton acreage when plenty of land is available. Besides reducing the incidence of boll rot (Ranney, 1964), it resulted in increased yields per acre because the skipped area was not counted as part of the allotted acreage (Bruce, 1965).

The main objectives of this investigation were to study (1) the influence of leaf shapes on plant microclimate and consequently on the survival of immature boll weevils and the incidence of boll rot and (2) the suitability of okra and super okra leaf shapes to skip-row culture and also their effect on earliness, yield, and other important agronomic characters.

REVIEW OF LITERATURE

Leaf Shape:

The growing of an okra leaf type, as early as 1837, was reported by Brown (1927). Much later, Shoemaker (1909) reported that okra leaf plants were found among the varieties grown at that time viz., Jones Improved, King, and Shine. He further stated that there were more okra leaf plants in the King variety than in the others. That the okra leaf shape originated as a mutation in a commercial Acala variety he used, was reported by Stephens (1945). Brown and Cotton (1937) reported the finding of an okra leaf plant in a field of Delfos variety of cotton on the Louisiana Agricultural Experiment Station Farm.

Cook and Doyle (1927),comparing the yields of okra leaf and normal leaf Acala in North Carolina and South Carolina in 1924 and 1925, reported that the okra leaf Acala yielded somewhat lower than the normal leaf type. In a similar study in California in 1925, they reported that, in 8 of 11 comparisons at one location, okra leaf yielded somewhat more than the normal leaf type, but at another location the opposite results were obtained. They also observed that the okra leaf type was earlier than the normal leaf type. It was suggested that this earliness might be the result of its sparse foliage. They thought that the soil may be warmer and the air drier due to much less shade in the okra leaf type than in the normal leaf type. They also opined that the boll weevils would have less protection from the open foliage and more of the weevil larvae might be killed in the fallen squares lying on the ground in the okra leaf Acala. Ware (1933), from the study of the genetic relations of Nankeen lint to plant color and leaf shape, stated that the okra leaf shape was a character that did not appear to interfere with economic production of lint.

Hutchinson (1936) reported that, in India, narrow leaf types generally predominate in areas of low rainfall and short monsoon season where the crop has to withstand a rapid on-set of dry conditions at the time of ripening, and broad leaf types predominate where soil moisture is maintained at the end of the season.

Brown and Cotton (1937) tested an okra leaf strain of Delfos cotton in comparison with adapted broad leaf varieties for several years during the 1930's, in Louisiana. They reported that the okra leaf type bloomed at a 50% higher rate and had fewer rotten bolls than the broad leaf varieties, but the yield of the okra leaf strain was below the average of the broad leaf varieties tested. They stated that "... the light foliage is a hindrance in that the ground is not shaded enough to prevent the rank growth of grass and weeds in the cotton after it was layed-by". Probably poor weed control could be one reason for the lower yields observed for okra than normal leaf cotton. The preliminary report of the Louisiana Agriculture Experiment Station Crops and Soils Department, for the years 1933 to 1936 (Anonymous), revealed that the okra leaf strain of Delfos cotton being studied by Brown and Cotton was within the range of the varieties tested in yield, lint percentage, and fiber length, but it was always among the lower half of these varieties for yield. It was also reported that there was less boll rot on the okra leaf strain than on the broad leaf strains and probably less weevil damage.

Cain (1948) reported no significant differences between the okra, intermediate, and normal leaf types in a study involving F_2 plants obtained from a cross between a synthetic line 7-9 and Coker 100.

Kohel, Lewis, and Richmond (1965) studied near isogenic populations of their marker stock after six backcrosses to TM-1. Individual F_2 plants homozygous for the contrasting leaf shape genotypes were measured for lint yield and other important economic characters. They reported that the okra leaf had no detectable influence on fiber length, fiber strength, or fiber elongation, but it had a negative effect on micronaire, lint index, lint percentage, and lint yield. There was evidence to suggest that the effects of okra leaf could be due to linkage rather than pleiotrophic effect.

Jones and Andries (1967) studied the effect of okra leaf shape on boll rot, yield, and other important economic characters at Baton Rouge and St. Joseph, La. They reported a 50% reduction in the average incidence of boll rot in the okra leaf treatment as compared with near isogenic population of normal leaf. Okra leaf was five days earlier than normal leaf type. Leaf type did not affect the yields at either locations. Okra leaf shape had shorter fibers than normal. In another study involving okra leaf shape and mixed populations of okra leaf and normal leaf shapes at three locations in Louisiana, Andries et al. (1969) reported the following conclusions. As an average of varieties and locations, okra leaf shape caused a 45% reduction in boll rot over the normal leaf type. The yield of okra leaf biotypes exceeded the yield of the mixed leaf and normal leaf treatments at each location. The okra leaf biotypes were substantially earlier than mixed leaf and normal leaf treatments at each location. The okra leaf plots could have been harvested 5 to 8 days earlier than normal leaf plots if the first picking could be delayed until 70% of the crop is open. The okra leaf character did not have any significant effect on boll weight, fiber length, length uniformity, or fiber strength. A significant increase in lint percentage and micronaire value was observed with the okra leaf character. Okra leaf plants had only 59% of the total leaf area of the normal leaf plants.

Baker and Weaver (1971) reported that the okra leaf was not consistent in its effects and suggested that there may be an okra leaf x genetic background interaction. Some okra leaf strains were no better or in some cases had greater boll rot losses than their normal leaf counterparts. They observed that under extreme boll rot conditions, okra leaf had very little advantage over normal leaf cottons. Major Jr. (1971) reported that, in a year of very low boll rot conditions, there was no difference between okra leaf shape and its normal leaf counterpart in the incidence of boll rot.

Andries (1972) reported that there was no significant difference in yield between okra and normal leaf isogenic strains. Okra leaf had a lower lint percentage than normal leaf. Okra leaf was also earlier than normal leaf.

Bird (1973) suggested that okra leaf shape gave a 13% gain in healthy bolls which was associated with a 9% gain in yield.

The earliest reference to the super okra leaf character was the super okra leaf mutation reported by Harland (1932). He reported that the super okra mutation may have originated in a planting of Acala okra leaf cotton in Trinidad. According to Stephens (1945) and Green (1953), the super okra leaf character is controlled by one pair of genes and is a member of an allelomorphic series having a minimum of five members: L^s (super okra), L^o (okra), L^e (Sea Island), L^u (sub okra), and l (normal). Very few published reports are found on the effects of super okra leaf shape on the incidence of boll rot, yield of lint, and certain plant and fiber characters. Andries et al. (1970) reported that super okra leaf shape caused approximately 55% reduction in the incidence of boll rot over normal leaf shape. Super okra leaf shape yielded lower than its normal counterpart, but was 12 days earlier than normal leaf if harvested when 70% of the crop was open. Boll weight, fiber length uniformity, and fiber strength were not affected by leaf shape. Super okra was associated with a significant increase in lint percentage and micronaire value and a significant decrease in fiber length and fiber elongation. The super okra plants had only half as much leaf area as the normal leaf plants. Almost similar results were reported by Andries (1972). Bagga et al. (1973), in his studies on influence of different row widths on boll rot potential, yield, etc., at Verona, Miss., reported that super okra leaf (Stoneville 7A background) had the least boll rot among all the varieties tested.

Skip-Row Planting:

Under the allottment of the Agricultural Stabilization and

Conservation Service (ASCS), only the acreage actually planted to cotton in a skip-row pattern is charged against the farm allotment. There are several skip-row patterns among which the 2 x 1, 2 x 2, and the 4 x 2 patterns are more popular. The first figure relates to the number of rows planted while the second figure indicates the numbers of rows skipped.

Cooke Jr. and Heagler(1964), reporting their work on skip-row planting in 1962 and 1963 in Yazoo-Mississippi Delta, observed that 2 x 1 skip-row planting gave an average increase in yield of 35 and 32% on sandy and loam soils, respectively, over solid planting.

Bruce (1965) reported that the yield of seed cotton per unit length of row from 2 x 1 skip-row planting was 27 to 34% higher than that planted in solid rows. He attributed this yield increase partially to the additional soil water available to the plants planted in skip-rows.

Significant increases in yield from 4 x 4, 4 x 2, 2 x 2, and 2 x 1 skip-row plantings over solid planting were reported by Melville and Oakes (1966). Tests conducted in 1962 and 1963 indicated that 2 x 2 skip-row planting gave the highest increase in yields. Average increase in yield was 63% on clay soil (Miller clay) and 66% on sandy soils (Yahola very fine sandy loam) due to 2 x 2 skip-row planting. The 4 x 4 and 4 x 2 skip-row plantings respectively, gave a yield increase of 35 and 34% on clay soils and 39 and 42% on sandy soils. As an average of 1964 and 1965 data, 2 x 2 skip-row planting again gave the highest increase in yields over solid planting, a 86 and 81% on clay and sandy soils respectively. The 2 x 1 pattern gave an average of 62 and 41% increase in yields over solid planting on clay and sandy soils, respectively. The 4 x 2 pattern gave an increase of 60 and 50% in yields on clay and sandy soils, respectively.

Bridge, Meredith, and Chism (1967) tested Stoneville 213, Deltapine Smooth Leaf, Acala 4447, and Deltapine 5540 cotton varieties under 2 x 1 and 2 x 2 skip-row plantings in Mississippi in 1965 and 1966. Yields were increased over solid planting by an average of 33 and 52% under 2 x 1 and 2 x 2 skip-row patterns, respectively. They reported that Stoneville 213 showed a much greater response to skip-row planting than other varieties. Skip-row plantings increased staple length of all varieties but had no influence on fiber strength or micronaire values.

Hawkins and Peacock (1968) reported that in field trials with 10 cotton varieties, average lint yields were 30 and 68% higher in 1963 and 1964, respectively, from 2 x 2 skip-row planting than from solid planting. In trials from 1959 to 1964, average lint yields from skip-row planting were 42% higher than from solid planting. The percentage of seed cotton yield harvested at first picking was significantly higher in solid rows than in skip-rows.

Boll size and fiber length were significantly higher from skip-rows than from solid rows.

Parks, Overton, and Measelles (1969) reported that in field trials conducted from 1964 to 1966 in Tennessee, highest yields were obtained from 1 x 1 skip-row planting compared to 2 x 1, 3 x 1, 4 x 1, and 5 x 1 patterns. They concluded that yields decreased with increase in distance between skip-rows.

Baker, Verhalen, and Murray (1970) also reported increase in yield of lint due to 2 x 1 skip-row planting over solid planting. They found that 2 x 1 skip-row planting resulted in taller plants, larger bolls, and a lower percentage of crop harvested at the first picking over solid planting.

Hawkins and Peacock (1964) summarized the advantages and disadvantages of skip-row planting as follows:

Advantages: Increased yield per allotted acre, circulation of air and penetration of more sunlight reduce disease losses and facilitate insect control. Extra moisture and more plant food is available from unplanted areas; wheel damage from cultivation and spray equipment is greatly reduced; more lateral branches with more bolls per branch are produced and also an increase in the number of bolls set from flowers opening in mid and late season.

Disadvantages: More land, extra labor and time are needed to prepare for planting. It may not fit into the crop rotation system.

Aerial spraying and weed control are more expensive; leaching of nitrogen and loss of organic matter on exposed soil are to be considered; and defoliation may be more difficult due to large succulent plants.

Boll Weevil:

Boll weevil first invaded the United States in 1892 and since then has been considered as the major pest of cotton in the United States. Boll weevil complex can be separated into the sub-species: Anthonomous grandis Boheman, characteristic of the southeastern United States; Anthonomous grandis thurberi Pierce, characteristic of weevil found in Arizona, and an intermediate form found in Mexico, Texas, Central America, and Cuba (Warner, 1966).

The adult boll weevil is about one-fourth inch in length, varying from one-eighth to one-third inch, and with a breadth of about one-third of the length. The most conspicuous indication of the presence of the boll weevil in the field is the flaring and abscission of squares with characteristic punctures made by this pest.

After the deposition of egg, the puncture on the young cotton square is sealed with a transparent seal. If a square remains on the cotton plant, the tissue around the sealed puncture may proliferate and form a protuberance. These proliferations have been used by many as a criterion of egg deposition. Everett and

Ray (1962) reported a high correlation between sealed punctures and eggs ($r = 0.92$ to 0.94).

Most of the punctured squares fall to the ground and the length of the time squares remain on the plant after oviposition varies, as reported by several workers. Hunter and Hinds (1905) observed that a small percentage of punctured squares remained on the cotton plants but that most of the egg-punctured squares fell to the ground after an average period of 9.6 days. Fenton and Dunnam (1929) reported this duration to be an average of 7.35 days after the square was punctured once for egg deposition, 7.02 days following two punctures, 7.08 days after three punctures, and 6.53 days after 4 to 6 punctures. Fye and Bonham (1970), discussing the effect of summer time temperatures of soil surface on the survival of boll weevils from fallen squares, stated that their unpublished data showed that the fall of punctured squares started on the second day after puncture, and by the eleventh day, about 48% of the punctured squares had dropped from the plant. About one-third squares did not fall.

Under normal conditions, an egg hatches in about three days and the larva immediately begins to feed. The larva takes 7 to 12 days to pass into the pupal stage. In about 3 to 5 days later an adult emerges and in about five days later, the adult (female) weevil begins oviposition. Climatic conditions cause variation in the duration of the stages, but on an average, it requires 2 to 3 weeks for the weevil to develop from egg to adult (Hunter, 1917). Black and Leigh (1963) reported that the average duration from egg to adult was 19.31 days for Deltapine-15 variety, at 82 F ($\pm$ 2 F). Jenkins et al. (1964) reported this duration to be an average of 16 days. Fye et al. (1969) in an experiment investigating developmental periods at several constant and fluctuating temperatures, found that the developmental periods of five strains of *Anthonomous grandis* Boh., from cultivated cotton, ranged from 88 days at 15 C to 17.5 days at 30 C. Fenton and Dunnam (1929) observed that the average period of development of the boll weevil in picked squares (boll weevil oviposited) when placed in the insectary was 14.42 days. Hopkins et al. (1969) reported that the length of the developmental period ranged from 13 to 30 days for the first generation.

Some of the more important cultural practices recommended in earlier years for the control of the boll weevil were preparation of seed bed, early planting, seed treatment, planting of a recommended variety, soil improvement and fertilization, frequent shallow cultivation, clean up of favorable hibernation quarters, and early destruction of cotton stalks (Gaines, 1952). The availability of chlorinated hydrocarbon insecticides soon after the World War II changed the control situation completely. The spectacular success of these pesticides resulted in almost complete control of boll weevil and increased yields. Consequently, the demand for indeterminate cotton varieties that are longer fruiting and high yielding increased. But, the application of broad spectrum organic insecticides directed towards the boll weevil resulted in almost total destruction of the beneficial arthropod populations in cotton fields, like predators and parasites, which led to the out-break of the bollworm-tobacco budworm complex in cotton (Ridgway et al. 1967 and Walker et al. 1970). The development of resistance to the chlorinated hydrocarbon insecticides by the boll weevil (Roussel and Clower, 1955), and later but similar results on the other pests of cotton (Adkisson and Nemec, 1966; Carter and Phillips, 1968; Nemec and Adkisson, 1969) emphasized the need for alternate methods of controlling the insect.

In the search for host plant resistance in cotton to boll weevil, emphasis was placed on host evasion and morphological characters thought to limit destructiveness of the insect (Cook, 1904a, 1904b, 1906, and Ware, 1936). Characters considered to be of possible value were effective proliferation, small involucral bracts, excessive hairiness, small leaves, thick boll walls, extra floral nectaries, determinate growth, and rapid growth of young bolls.

Stephens (1959) suggested that hairiness may be a source of resistance. That the resistance is conditioned by length, density, and position of pubescence was reported by Wannamaker (1957). Based on his laboratory data, Stephens (1959) noted that the presence of glands is an important factor in attracting weevils to the cotton plant and was possibly important in stimulating oviposition. Painter (1951) mentioned leaf color as one of the factors responsible for host plant resistance. Boll weevils were reported to exhibit marked preference for cotton plants with green foliage to those with red foliage, when choice is available (Isley, 1927, 1928) and this was later confirmed (Wessling, 1958b, and Hunter and Waddle, 1958). Another non-preference morphological character is frego-bract in cotton (Jones et al. 1964; Hunter et al. 1965; and Lincoln and Waddle, 1966).

Leaf size is another important morphological character involved in host plant resistance. It was established that a heavy foliage is favorable to the boll weevil and so it is assumed that plants with relatively smaller leaves may be less succeptible. Isely (1928) investigating the relation of leaf color and size to boll weevil infestation, observed that, in 1925, the okra leaf was more heavily infested than the broad leaf variety; the ratio being 33.5 for okra and 22.5 for Lone Star, where okra leaf was used as a small leafed variety and Lone Star from Texas was used as broad leafed variety. The increased infestation on okra was accounted for by the fact that the plants on one of the okra leafed plots were unusually luxurient due to more fertile soil. In 1926 the broad leafed Lone Star was slightly more heavily infested than the okra leafed Acala. The summaries of infestations were: August 17- Lone Star, 32.75%; Okra leaf, 29.75%; August 24- Lone Star, 57.75%; Okra leaf, 41.20%; August 31- Lone Star, 70.00%; Okra leaf, 66.00%. No significant advantage because of leaf size (okra) was found.

Merkl and Meyer (1963), in their studies on resistance of cotton strains to boll weevil, tested Pilose-Okra leaf (actually super okra leaf) as one of the strains. The Pilose-Okra had dense hair on it and the leaf was of super okra leaf shape. Their results showed that this strain had a low percentage of squares punctured under conditions of low weevil pressure, but when weevil infestations increased markedly on other plots a rapid increase in infestation occurred on these plots.

Reviewing literature on boll weevil, Cross (1973) stated that 42 species of arthropods are known as parasites on the boll weevil. He stated that there is evidence of increasing parasitism of the boll weevil. Bracon mellitor was much the most important and accounted for 74.5% of the parasites and Aliolus curculionis (Fitch) and Eurytoma gossypii Bugbee ranked as second and third according to studies made in 1965 by Chestnut and Cross (1971). Johnson et al. (1973) suggested the potentiality of Hetero laccus

Burks as a parasite of boll weevil in United States. It is a primary parasite of boll weevil in parts of Costa Rica, Nicaragua, Guatemala and Mexico.

Although the possible production of offsprings in a single season, by one pair of weevils, has been estimated at 12,755,100, as a matter of fact, nature has provided a number of agencies to prevent such excessive multiplication. The most conspicuous of these agencies are heat and insects that prey upon the weevil (Hunter, 1917). Climate exerts a very important influence upon the seasonal cycle of the cotton boll weevil. Hot, dry summers are also unfavorable. The frequency of rains as well as the total rainfall has an important bearing on boll weevil development (Fenton and Dunnam, 1929).

When infested squares fall to the ground, they may become so heated that the larvae may be killed in a few minutes. The insect in the larval stage cannot leave the square as it has no means of locomotion whatever. Where the infested squares are subjected to the unobstructed rays of sun, the mortality is very high. Occasionally, as many as 90% of the immature weevils in cotton fields inspected were found to have been destroyed through this agency. The extent of destruction holds a close relation to the amount of shade. When there is no shade, practically all of the larvae and pupae would be killed.

Hinds (1907), discussing some factors in the natural control of boll weevil, gave a very interesting account of the effect of weather on the survival of boll weevil. He observed: "If there is a fair amount of moisture in the soil upto the time squares begin to form, and there then ensues a period of from 4 to 6 weeks of hot dry weather, it may be expected that the weevils, though abundant, may be so effectively checked as to do little injury to the crop of that season. An entire season of extreme drought, even without exceptionally high temperatures, will greatly reduce the number of boll weevils. Fallen squares contain fully 70% of the weevil stages developing in a field. All factors of natural control seem to operate more effectively against weevil stages in squares than against those in bolls. Ants and heat are the most important factors. The effectiveness of heat from sunshine is largely influenced by spacing of plants., which should be wide for best results, and by the coincidence dryness of soil or atmosphere. The mortality from heat in two groups of localities having almost identical mean maximum temperatures varies as widely as between 7 to 20%. Exact reasons for this great difference are not apparent. Average climatic variations do not appear to produce a corresponding variation in the average mortality of weevil stages. The highest mortality was found at Corpus Christi, Texas, in coincidence with comparatively low average maximum and mean temperatures, but after an exceptional drought extending over some eight or ten weeks. This occurred also in well-tilled field where not more than one-half of the ground was shaded. The proportion of clear to cloudy days and the relative rainfall seem to influence in considerable degree, the effectiveness of high temperatures". He also reported that nearly 70% of all mortality found from heat or drying occurred during the larval stage and the ratio of mortality percentages in each weevil stage from heat was adult 1 : pupa 3 : larva 9. It may be mentioned that the data were collected from 28 localities and include 2 to 9 dates between June 15 to October 15, 1906.

Pierce et al. (1912) found that the maximum fatal temperature to the boll weevil was 123 F, a temperature frquently reached on a hot burning soil. The minimum fatal temperature to the boll weevil was reported to be 12 F. They also reported that the climate-accounted-for mortality in fallen squares was 25.7% in Arkansas, 12.5% in Louisiana, 37.9% in Texas, 30.8% in Oklahoma, and 11.7% in Mississippi during the years from 1906 to 1909. It was found that, as an average of all locations, the mortality due to climate was 31.2, 33.5, 20.3, and 26.6% in 1906, 1907, 1908 and 1909, respectively.

Fenton and Dunnam (1929), studying the biology of boll weevil at Florence, South Carolina, observed that during the months of July and August of 1925, the mortality of weevils from heat averaged 41.18% in fallen squares. It increased from 16.95%, July 2, to 70.09%, August 17. There was considerable variation in the mortality in fallen squares in different fields during the same periods; this ranging from 35.81 to 48.38%. In 1926, the mortality from heat in fallen squares varied from week to week, with a peak of 48.7%, July 2. Later there was a marked drop for two weeks, followed by increases until a second peak reached on August 18. Variation between different fields ranged from 7.51 to 38.99%. They mentioned that there was markedly below normal rainfall during those months of high mortality and the temperatures were also considerably higher than normal.

The importance of climate in controlling weevils was recognised even earlier. Cook (1911) observed that the propagation of weevils is less rapid in dry regions and dry periods. Wet weather favors rapid multiplication of the weevils. He further commented that it is not safe to assume that improved cultural methods, earliness of varieties, or special weevil resisting characters will have the same value in humid regions that they may have shown in dry seasons in Texas. In the absence of the limiting factor of drought, it is not safe to assume to apply the analogies drawn from Texas to more eastern states, he observed.

Fenton and Hixon (1935), in an investigation to determine the effect of the 1934 drought in Oklahoma on boll weevil, noted that "The most striking feature of the drought was the marked deficiency of rainfall every month except September and November, for the entire section of the state. The total rainfall from May to August inclusive, was 4.6 inches in the southeast and it was 12.3 inches deficient than average. Absolute maximum air temperatures have a significant impact on boll weevil survival. Although these temperatures in themselves are not fatal to the boll weevil, their effect is to heat the surface soil, particularly if it is dry, to excessively high temperatures. Surface soil temperatures sufficient to cause high mortality of weevil stages in fallen squares were reached almost daily for a period of approximately two months. The actual peak of the heat wave began on June 20 and extended through August 21. Maximum temperatures were recorded and only temperatures from 100 F and up were considered. At one location, 61 out of 73 days had maximum temperatures of 100 F or above. Temperatures as high as 112 F were recorded in two cases, with the greatest frequency at 101 and 105 F. The effect of above combinations of climatic conditions was to accelerate shedding of fruit on the cotton plants and kill most of the immature weevils in fallen squares and young bolls on the ground. Examinations showed that few immature weevils were surviving. On August 11 and 13, over 2000 hanging and fallen dead squares and bolls were examined in two representative fields. The mortality due to heat ranged from 77.5 to 84.0% in fallen squares and from 33.3 to 54.0% in dead hanging forms. The cotton in the field having the lower mortality was a broad leafed variety with a fairly rank growth, thus giving maximum shade protection. A marked drop in mortality occurred in September when there was adequate rainfall".

During the cotton fruiting seasons of 1929 to 1932 inclusive, collections of fallen and hanging cotton squares were made at approximately 15-day intervals during June, July, and August from eight fields in Madison Parish, Louisiana, selected to include several soil types of this locality (Smith, 1936). Temperature and rainfall data were also collected. The report showed that the total mortality of the weevil stages in the fallen squares was 11.42% in 1929, 41.33% in 1930, 15.33% in 1931, and 24.08% in 1932.

In only one year, 1930, out of the four years in which those studies were made, was there a dry season during June and July. Apparent correlations not only with the rainfall over the preceding 15 days (a period approximately covering the total larval and pupal stages of the boll weevil) but also with both mean and the highest maximum temperature over the same period was found. When the mean maximum temperature was plotted against weevil mortality, it indicated that with the average maximum temperature every day approaching 93 F, temperatures developed upon the ground were sufficient to be lethal. The curve for the highest maximum temperatures for the same periods showed that the mortality was the result of long discontinuous exposure to such temperatures as there was a very distinct correlation between the height of the highest maximum temperature and the percentage of boll weevil mortality. The low point again was some where near 93 F and rapidly increased to the highest point recorded (50% mortality) at maximum temperatures approaching 105 F. They opined that the actual lethal temperatures must be considerably higher and may be developed only in contact with some surface such as soil, since as high as 105 F produced little, if any, excess in mortality of boll weevil stages in squares hanging freely in the air.

They also predicted that, with rainfall much less than an inch and a half over the 15-day period, mortality was likely to be high while precipitation in excess of that amount tended to reduce mortality. They further observed that the relation between rainfall and mortality is also tied up with temperature, which should vary inversely with the amount of precipitation owing mostly to the immediate cooling effects due to large quantity of heat required to effect the slow evaporation of moisture from the soil.

They concluded that continued high temperatures are not necessary to effect kill unless those temperatures are of relatively low maxima that is, of the order of 90 to 94 F. A single day much above 95 F is sufficient to produce heavy mortality of the boll weevil in stages in contact with the earth and fairly exposed to the action of the sun, they noted.

Fye and Bonham (1970), in their investigation "summer temperatures of the soil surface and their effect on survival of boll weevils in fallen cotton squares", concluded that mortality in populations of immature boll weevils in fallen squares on the soil surface commenced when the summation of the index of time (1-hour period) x temperature above 38 C (100.4 F) reached 60. All the weevils died when the summation reached 550. They observed that soil surface in Arizona cotton fields attains a mean temperature of 38 C when the air temperature is 30 C (86 F). Soil surface temperatures of 38 C are common when air temperatures are lower than 30 C and may reach 60 C when air temperatures are at maximum. Frequent and prolonged periods with temperatures above 38 C impose a strong bioclimatic control on the boll weevils until late season when shading by mature cotton plants enables the survival of the immature weevils in the squares on the soil surface, they opined.

Jones (1972) studied the effects of super okra leaf shape on the survival of immature boll weevils in cotton fields. He found that there was a significant increase in the mortality of boll weevil stages in fallen squares under the super okra leaf plant canopy compared to normal leaf plant canopy, during hot dry periods.

Boll Rot:

Cotton boll rot is a combination of several diseases of the cotton fruit. These diseases may partly or entirely destroy the immature bolls, or may ruin the seed and decay the fiber. The rot is caused by a number of microorganisms which presumably remain dormant over the winter in the soil and seed and resume their normal vegetative activity around the lower portions of the plant near lay-by time or soon thereafter when the ground becomes shaded and moist as a result of rank growth (Chilton and Pinkard, 1966).

Though cotton boll rot probably had been noted since the cultivation of cotton started, the earliest record of technical value was probably by Wailes (1854) who gave a general description of decayed bolls. Atkinson (1891), Southworth (1891), and Stoneman (1898) were the first to work on the then most destructive organisms causing decay of cotton bolls, Colletotrichum gossypii South causing anthracnose and Xanthomonas malvacearum (ESF) Dows responsible for angular leaf spot. Atkinson (1891, 1892, 1896, 1897) studied the boll rot problem at the Alabama Experimental Station and described many of the fungi and bacteria which were responsible for the rots.

Barre (1913), Edgerton (1912, 1916) and others of this period worked on the life-history, economic importance and partial control of these organisms. Edgerton (1912) reported that Glomerella gossypii, Bacterium malvacearum, Diplodia gossypina, Fusarium spp., Rhinatricum tenellum, and Olpetrichum corpophilum were the principal causal organisms. Barre (1913) showed that disease-free seed could control the anthracnose organism. Smith (1920) reported that the angular leaf spot bacterium is a soil borne as well as a seed borne organism and so cannot be controlled by means of seed treatment alone in some areas.

Defining cotton boll rot as cotton fruits which decay before the fibers have fluffed out through the natural process of maturation, Pinkard (1964) emphasized the importance of environment in boll rot development. He reported that bolls of all ages are prone to decay under suitable conditions. He suggested that the degree of boll destruction also depends on suitable environment for the causative organisms, besides two other factors. Pinkard concluded that "... with some exceptions, the nature of environment surrounding the bolls and the portion of the whole plant on which the boll is produced appear to be the key to our major boll rot diseases in Louisiana". Edgerton (1912) was probably one of the earliest workers to point out the role of weather in boll rot. He suggested that weather was the most important of the several factors responsible to increase or decrease their attack and that the conditions of excessive rainfall and humidity favored the development of boll rots.

Pinckard and Chilton (1966) listed _Fusarium_ _spp_., _Diplodia_ _spp_., _Glomerella_ _gossypii_ Edg., _Pestolatia_ _spp_., and _Pellicularia_ filamentosa (Pat) Rogers as the most important fungi responsible for boll rot in Louisiana. They further noted that their occurrence and order of importance are subject to the environmental, seasonal, or cultural circumstances.

Use of high levels of nitrogen and moisture causes rank growth which provides generally favorable conditions for the growth of boll rot organisms. A direct relationship between these variables was suggested by Scarsbrook et al. (1961) and Ranney (1964). Ranney (1964) further stated that with the use of mechanical pickers, early bolls remain exposed to the environment for longer period of time which itself is a major factor favoring boll rot. Exposure of bolls for long periods with the combination of favorable environment for boll rot poses a serious problem.

Garber (1964) reported that bottom defoliation significantly reduced boll rot diseases but also reduced yields in three years of testing in California. He further stated that cultural practices to prevent rank growth proved to be most beneficial in reducing boll diseases. Such practices as wider spacing between plants within the row, avoiding the excessive use of nitrogenous fertilizers, and avoiding the tendency to over-irrigate helped to correct the problem of rank cotton. These pracitices in addition to skip-row planting reduced the boll disease problem to a minimum in California.

Ranney and Newton (1963) suggested the severity of the boll rot to be associated with the number of bolls opening during the period of adverse weather. Ranney et al. (1971) studied boll rot as affected by microclimate. Their studies under laboratory conditions showed that the fungi responsible for boll rot were seriously affected by only two climatic variables, temperature and moisture. They reported that opening the plant canopy by bottom defoliation or full defoliation resulted in 44% more sunlight penetration (at one foot level), higher temperatures, and shorter durations of 95% or higher relative humidity within the plant canopy. All these conditions may be less favorable for the development of boll rot organisms. They predicted that in areas of high rainfall such as Mississippi Delta, a normal fluffed cotton boll will result if good drying conditions prevail for 60 to 80 hours following splitting of the boll sutures. In contrast, if boll opening is initiated during periods of rainfall or continuing high humidity, the bolls can be severely damaged by rot organisms. The development of this type of rot is greatly influenced by the microclimate of the boll zone. Ranney (1964) also showed that 4 x 4 and 2 x 2 skip-row patterns reduced the amount of boll rot because they were more open than solid planting, facilitating more rapid drying and increased light penetration in the lower plant zone. Newton and Ranney (1964) also reported reduction in boll rot from 4.9% in check plots to 3.9% in bottom defoliated plots which substantiated their stand that the microclimatic changes induced by a more open plant canopy were less favorable for fungal and bacterial growth. Pinkard concluded that Pellicularia filamentosa (Pat) Rogers is a primary cause of cotton boll rot which grows in rank growth and where there is shade and high moisture conditions. He suggested that one method of control would be to grow varieties having an open growth habitat such as okra leaf types, which will permit sunlight to dry the surface of the plant and possibly maintain the natural resistance of plant.

Bagga and Ranney (1969) reported that incubation of undamaged and apparently healthy bolls showed that many bolls were infected (44%). The presence of microorganisms inside the boll constitutes infection potential for internal rot but not necessarily actual rot. Actual rot-loss depends upon environmental conditions during boll development and opening. The environment can inhibit, allow, or accelerate the development of rot in the infected boll.

Yet, another suggestion was made by Garber et al. (1966). In their studies they found that, in desert climate, even though the air moisture in a cotton field may be relatively high, not all bolls become diseased. Under similarly humid conditions, diseased bolls are consistently more prevalent at some locations than at others. In many instances, such variability within or between locations had been related either to the abundance of disease organisms or to favorable conditions such as high relative humidity. They stated that tests thus far did not indicate any striking relationship between the amount of carbohydrates present on the surface of cotton bolls and boll disease. They concluded that some as yet unidentified materials stimulate spore germination. The pH of the boll surface was found to be high enough to inhibit the germination of Rhizopus spores, so, maybe the pH of the boll surface is related to the presence of boll diseases at certain locations, they suggested.

MATERIALS AND METHODS

The tests consisted of three strains representing different leaf types, evaluated at two row spacing levels. 'Stoneville 7A', a commercial variety, represented the normal leaf shape which had broad leaves with shallow lobes. The okra leaf had somewhat deeper clefts, and the super okra leaf was very deeply lobed. Very often a mature super okra leaf consisted just one or two narrow straps. The two row spacings were the solid and skip-row patterns. The solid pattern consisted of regular planting on flat beds with 40-inch spacing between rows. In the skip-row pattern planting was done on the same flat beds spaced similarly but for every two rows planted, one row was skipped. This is called 2 x 1 skip-row planting pattern.

The seed of Stoneville 7A was obtained from the Stoneville Pedigreed Seed Company at the beginning of each season. The Louisiana Okra-2 (La. Okra-2) and Louisiana Super Okra-2 (La. Super Okra-2) representing okra and super okra leaf shapes, were developed after six backcrosses to the Stoneville 7A variety. No selection was practiced in the development of these strains except for leaf shapes and the last backcross to Stoneville 7A was made in 1967. It is recognized that there may have been some genetic change in the Stoneville 7A variety after the last backcrosses were made, but these changes, if present, would probably have been of a relatively minor nature. Therefore, these three cottons for this study were considered to be near isogenic for leaf shape.

The design of the experiments was a split-plot factorial with the row types as main-plot treatments and the three leaf shapes as sub-plot treatments. The tests were conducted at Baton Rouge and St. Joseph for three years, 1971, 1972, and 1973. The treatments were replicated six times except in 1971 at St. Joseph when they were replicated five times. Each plot consisted of six rows and were 30 to 40 ft. long.

Treatments:

A. Main-plot treatments (row types):

1. Solid-row
2. Skip-row

B. Sub-plot treatments (leaf shapes):

1. Stoneville 7A (normal)
2. La. Okra-2 (okra)
3. La. Super Okra-2 (super okra)

BATON ROUGE

The tests for all three years were conducted at the Agronomy Research Farm situated on Perkins Road, Baton Rouge, La.

1971: The field (Essen silt loam) was layed off in rows on

40- inch centers. The beds were disked lightly prior to applying fertilizers. The test area was fertilized on April 19 with 400 lb/acre of 10-20-20 fertilizer, applied in water-furrow and then disked and rebedded. No fumigation was done in 1971.

Just prior to planting, the beds were dragged down to a height of about 4 inches with a 'Do-All' row conditioner. Trifluralin (Treflan) was applied at the rate of 0.75 lb/acre on 20-inch band and incorporated with a W & A soil incorporator. Terraclor Super-X was applied at a rate of 0.5 gal/acre as in-furrow spray at the time of planting. Planting was done on May 18 with a seed rate of six live seed per foot and later thinned to a stand of three plants per foot before squaring. The test was side-dressed on June 25, with 190 lb/acre of nitrate of soda. The total fertilizer applied was 70-80-80 lb/acre of N-P-K. Regular insecticide schedule was initiated on June 30, using a mixture of 2 + 1 + 0.25 lb/acre of Toxaphene-DDT-Methyl Parathion, respectively, and continued on a 3 to 5 day schedule until September 24. Additional weed control was accomplished by the application of 1 lb/acre of flurometuron (Cotoran) + 1.7 lb/acre of MSMA + surfactant on a lay-by spray made on July 13. Mechanical cultivation and hand hoeing also helped in controlling weed growth.

A twenty-foot section in one of the center rows was marked-off for measuring yield. Harvesting was done by hand picking at about weekly intervals. Pickings were made on September 22, 28, October 4, 11, and November 4.

1972: The 1972 test was conducted on a different plot than the one used in 1971. The soil type was Olivier silt loam.

The field was flat broken to a depth of approximately 10 inches, with a mold-board plow in the fall. It was laid off in rows on 40-inch centers in early March. The test area was fertilized with a basal application of 400 lb/acre of 10-20-20 fertilizer on April 11, applied to the center of bed at 4 to 6 inch depth. Fumigation was also done on the same day with 9.1 lb/acre of DBCP (Fumazone) for the control of nematodes. The beds were disked lightly prior to applying fertilizer and rebedded after the nematicide application.

Just prior to planting the beds were dragged down to a height of four inches with a 'Do-All' row conditioner and trifluralin (Treflan) was applied broadcast at the rate of 0.75 lb/acre, incorporated with a rotary hoe; the beds were firmed with a cultipacker. Terraclor Super-X was applied as an in-furrow spray at the rate of 0.5 gal/acre. A two-row planter was used to mark-off the test area so that two-row cultivating equipment could be used. The test was planted on April 25, using a push-type hand planter, with a seeding rate of 6 to 8 seed per hill, 12 inches apart on 40-inch rows. The test was thinned to three plants per foot prior to squaring.

Side dressing with 150 lb/acre of nitrate of soda was done on June 13 bringing the total fertilizer application of 64-80-80 lb/acre of N-P-K respectively. On the same day, 0.5 lb/acre flurometuron + 0.8 lb/acre of MSMA (equivalent of 1.5 lb/acre of DSMA) were applied as a directed spray on a 20-inch band to control weeds. Hand weeding was done from time to time to accomplish satisfactory weed control. A lay-by application of diuron (Karmex 80% WP) at a rate of 0.5 lb/acre + 1.25 lb/acre of MSMA (equivalent of 2.25 lb/acre of DSMA) + surfactant was made on July 20.

Application of insecticides was begun on June 14 with 0.1 lb/acre of Cygon applied to control plant bugs. The regular insecticide program was intiated on June 26 using a mixture of 2 + 1 + 0.25 lb/acre of Toxaphene + DDT + Methyl Parathion respectively, and continued on a 4 to 7 day schedule till September 11. Applications were made with a 8-row John Deere Hy Cycle sprayer. Down rows of fill-in cotton were provided for travel to prevent mechanical damage from the sprayer to the test rows.

The test was harvested by hand at about weekly intervals on the following dates: August 29, September 6, 12, 19, October 5, 12. A total of seven pickings were made. The yield was obtained from a 20-ft. section of one of the two center rows marked-off earlier.

<u>1973</u>: The 1973 test was conducted in the same field as in 1972. The randomization of main plots was kept as in 1972 to avoid variation due to residual skip-row effects. However, sub-plots were re-randomized.

The test area was fertilized on May 2, with 400 lb/acre of 10-20-20 fertilizer in a 4-inch band to the side of drill and bedded-up. It was fumigated on May 10, with 6.1 lb/acre of DBCP (Fumazone). Trifluralin (Treflan), at 1.5 lb/acre, was applied broadcast at planting, after beds were dragged down and incorporated with a rotary hoe. Terraclor Super-X, at the rate of 0.5 gal./acre in 16 gal. liquid per acre, was applied as an in-furrow spray at planting time. The test was planted on May 15 on 40-inch beds using a two-row cone-type planter. Seed was planted at a rate of 6 to 8 seed per hill. Later, the test was thinned to three plants per foot prior to squaring.

On June 12, 0.5 lb/acre of flurometuron (Cotoran) + 0.8 lb/acre of MSMA (equivalent of 1.5 lb/acre of DSMA) + surfactant were applied as a directed spray on a 20-inch band for weed control. Side dressing with 30 lb/acre of N through ammonium nitrate (33% N), dissolved in 10 gal/acre of water, was made with a tractor-mounted rig on July 6. Diuron was applied as a lay-by on July 31 at the rate of 0.5 lb/acre in 19 gal/acre of water.

A mixture of Toxaphene + Methyl Parathion (4:1) was applied on May 31, at the rate of 2.5 pt/acre to control thrips. Regular insecticide program was initiated on June 29 with 3 pt/acre of the mixture until July 10 and later increased to 4 pt/acre on a 3 to 5 day schedule until August 29. The insecticide program was discontinued prematurely since rains prevented insecticide applications for first two weeks in September. Azodrin (0.25 lb/acre) was also applied on August 15 and 20 for spider mite control. The insecticides were applied with a 12-row John Deere 660 Hy Cycle sprayer. The sprayer was allowed only in the border rows of the plots to avoid mechanical injury to plants and equipment in the test rows of each plot.

Harvesting was done by hand picking at about weekly intervals on a 20-ft section marked-off earlier in the two center rows. A total of five pickings were made on the following dates: October 4, 9, 17, November 2, and December 6.

ST. JOSEPH

The soil type on which the tests were conducted was Commerce silt loam.

<u>1971</u>: The field was disc harrowed, bedded into rows and dragged down in late spring. It was fertilized with 62 lb/acre of N in the form of anhydrous ammonia, on March 24, applied in the

center of the bed. Trifluralin, at a rate of 1 lb/acre, was applied broadcast on March 24 and disked-in. Beds were established with Hipping-Disc on 40-inch centers and left for planting. Dalapon, at a rate of 5 lb/acre, was applied approximately one week before planting for added johnsongrass weed control.

Planting was done on May 4, with a cone type planter, at a rate of six seed per foot. Terraclor Super-X was applied at a rate of 0.5 gal/acre as an in-furrow spray for seedling disease control. After emergence, certain errors in planting were discovered and corrected at the earliest opportunity. These replanted rows, however, were avoided in the collection of data.

Post-emergence weed control was accomplished by surface application of 1.2 lb/acre of flurometuron and two applications of diuron + MSMA + surfactant at the recommended rate. In spite of supplemental mechanical cultivation and hand hoeing, weeds, especially johnsongrass, remained a problem throughout the season.

Insects were controlled with regular applications of Toxaphene + DDT + Methyl Parathion mixture at recommended rates, at 5-day intervals. A total of 12 applications were made from July 21 through September. The test was defoliated with 1.5 pt/acre of Folex in late September.

Harvesting was done by hand picking a 20-ft section of one of the two center rows. A total of three pickings were made on October 22, November 4, and 23.

1972: The field was fertilized with 75 lb/acre of N in the form of anhydrous ammonia. Nitralin (1 lb/acre) was applied broadcast and incorporated prior to planting. The test was planted on May 11 with a cone-type planter on 40-inch rows at a seeding rate of six seed per foot. It was later thinned to a stand of three plants per foot before squaring. Terraclor Super-X (0.5 gal/acre) was applied as an in-furrow spray.

Immediately after planting, 1.5 lb/acre of flurometuron was applied as an over-lay herbicide. Two post-emergence applications of diuron + MSMA + surfactant were made at the recommended rates and manner to control weeds. This was supplimented with mechanical cultivation and hand hoeing whenever required to control weed growth.

The hail-storm that occurred on June 30, caused considerable damage to the crop. The plants lost most of their foliage. But the crop seemed to compensate by late regrowth.

Twelve applications of Toxaphene + DDT + Methyl Parathion mixture at the recommended rate were made at 5-day intervals to control insects. The crop was defoliated with 1.5 pt/acre of Folex in late September.

Harvesting was done by hand picking as in the previous year. Two pickings were made on November 15, and 30.

<u>1973</u>: The field was fertilized with 64 lb/acre of N in the form of anhydrous ammonia at the time of bedding. Trifluralin (1 lb/acre) was applied as pre-plant incorporated for weed control. Flurometuron (1.2 lb/acre) as surface over-lay application after planting and two post-emergence applications of flurometuron + MSMA + surfactant at the recommended rates provided excellent weed control. Cygon (0.1 lb/acre) was applied on July 12 and 23, for plant bug control. Methyl Parathion (1lb/acre) was applied at 5-day intervals, from August 4 to October 4, for control of boll weevil and bollworm. The test was defoliated with 1.5 pt/acre of Folex on October 4.

Harvesting was done in the same manner as 1972. A total of three pickings were made; on October 11, 24, and November 29.

CHARACTERS EVALUATED

<u>Soil-surface Temperature:</u>

In the preliminary studies done in 1971 at Baton Rouge, the soil-surface temperature was measured once in a day, within two hours after noon, with a regular thermometer. The mercury end of the thermometer was placed about two inches from the drill on the soil surface under plant canopy for two minutes before the reading was taken (two readings per plot). This was considered to be at or near the maximum temperature of the day. Measurements were taken in solid and skip-row plots and on both sides of the test rows (east and west). No data were obtained for no canopy. The temperature measurements were made in degrees Farenheit.

Temperature at the soil surface was measured and recorded by a 24-point Honeywell Electronik-15[R] recorder with copper-constantan thermocouples in degrees Farenheit for the Baton Rouge tests only, in 1972 and 1973. The soil-surface temperature under the different leaf-shape canopies (for solid rows only) and on open ground with no canopy was recorded on a 24-hour/day basis from the time of peak squaring till cutout stage (June 28 to September 7 in 1972, and July 26 to September 14 in 1973). The temperature was recorded from one probe at a time and at an interval of two minutes between probes. It took 8 minutes to complete 1 replication and 48 minutes to complete all 6 replications for each cycle.

The probes were placed within two inches of the center of the drill of the two test rows and pinned to the ground with 'U' shaped clips. The probes were moved every other day to different positions on the two test rows in order to sample the whole plot thoroughly. The temperature data of each plot were later summarized into daily maximum temperature and daily total degree-hours above 85, 90, and 95 F. Degree-hours are the summation of temperatures above a specified degree times the duration of the temperature in hours. Since each probe recorded the temperature every 48 minutes (48/60 = 4/5th of an hour), the degree-hours were calculated by multiplying the number of degrees above the designated temperature at each recording with 4/5 (hours). Average number of degree-hours above 85, 90, and 95 F, and average maximum temperatures were computed for the first week, second week, and both weeks of each batch of squares exposed in both years (1972 and 1973). These data were subjected to analysis of variance and covariance, with the weevil survival data.

Light Penetration:

The incident of light in foot-candles at the soil-surface under the three plant canopies (solid row only) and no canopy was measured by a Gossen-Trilux light meter. The light measurements were taken in the two test rows of each plot, at Baton Rouge, during clear sunshiny days within two hours of noon. The photo receptor was attached to a 4-foot handle with which to extend it so that light measurements were obtained without disturbing the canopy. The photo receptor was placed on the ground touching the stem of the cotton plant under its canopy to obtain the reading. At least five readings per plot, including the no canopy treatment, were obtained on each date of measurement. Light measurements were made on several days during July and August of 1972 and 1973. The time required to take one set of readings (one date, all plots) was about 50 to 60 minutes. Light measurements were not made in 1971.

Relative Humidity:

In the preliminary studies done in 1971, relative humidity was measured with a portable Atkins Psychrometer # 3Z02B, within two hours after noon, at soil level and at a height of 12 inches within the plant canopy. On two days, relative humidity within the plant canopy at a height of 24 inches was also measured. The dry and wet bulb temperatures were noted in the field and then converted into percent relative humidity.

During 1972 and 1973, relative humidity within the plant canopy was measured and recorded by a Weather Measure H-311 hygrothermograph. Data were collected during the boll maturation periods (July, August, and September). Since only six units were available, only two replications of the three leaf shapes were covered at a time for a given period. However, the recorders were moved frequently so that all plots were sampled. Each hygrothermograph was mounted on a slanting platform (4 inches high on one side and 2 inches high on the other side). This arrangement helped to keep the recorders on a levelled plane when they were placed resting on the ridge on one side and into the furrow on the other side. Each hygrothermograph was placed on one of the two test rows. The human hair sensor was placed about two inches away from the center of the drill and extended vertically from 4 to 12 inches above the ground. The hygrothermographs were covered with 1/8-inch gauge nylon net to avoid the direct splashing of rain water into the recorder and onto the human hair sensor, thus helping in keeping the instruments within calibration. It also helped in keeping the instruments clean.

During the 1972 summer, the hygrothermographs were moved every day from August 7 to 28, but they were moved every two days from July 21 to August 6 and from August 29 to September 29 due to the pressure from other work. In 1973, the hygrothermographs were moved from plot to plot every seven days due to concern for disturbing the calibration of the instruments, thus sampling only two replications a week. However, each instrument was moved three times a week within the plot so as to sample the two test rows of each plot. There was some difficulty with the recording pens of two hygrothermographs and for a while they could not be used. The clock of another recorder got damaged after some time and was out of commission for about three weeks. Therefore, data for only those periods when all three leaf shapes were covered within a replication were considered in this study.

Boll Weevil Survival:

The objective was to study the percentage of weevil survival as influenced by leaf shapes under field conditions. The study was made only at Baton Rouge. Both solid and skip row treatments were included in the investigation in 1971, but only solid row was included in 1972 and 1973. Medium sized oviposited squares were collected from plants of the Stoneville 7A variety planted for the purpose in a small isolated plot. After egg deposition, a transparent seal is left over the puncture. If a square remains on the plant, the tissue around the sealed puncture may proliferate and form a protuberance. These protuberances were used as a criterion of egg deposition in the field (Everett and Ray, 1962). Each week, on a stipulated day, such squares were collected in the morning. Fifty squares were spread per plot along the length of either inside row, each week. The squares were pinned to the ground with tooth picks through the bracts avoiding damage to the eggs. The squares were spread in rows of three, about 2 to 5 inches from the stem under the plant canopies, and at least one inch from each other. Only one of the two test rows was used at any one date and the site used for spreading the squares along the row was changed each date in order to sample the whole plot thoroughly. This proceedure was followed for all the years except that in 1971 when only 25 squares were spread each time (instead of 50), alternately on the east and west side of the row.

Several batches of squares were spread in 1971 (during July and August), in 1972 (from June 28 to September 7), and in 1973 (July 26 to September 14), extending over several weeks during the crop duration so as to cover the climatic variations within a season.

The squares were left in the field for two weeks and then collected and examined for the presence of an escape hole made by the emerging adult weevils or for the presence of a living or dead immature weevil. In 1971, after examining the exposed squares they were classified into only three categories, living, dead or undetermined when there was no escape hole or no live or dead weevil stage in the square. In 1972 and 1973, each square without an escape hole was classified into dead or living adults, pupae, and larvae as the case may be and into another category called undetermined, that is, squares in which there was no evidence of an escape hole nor the presence of a live or dead immature weevil. The undetermined class may be considered as dead since they might have died in the egg stage or early larval stage which, when decomposed, could not be identified. For practical purposes, only the squares with live weevils (adult or immature) and those with escape holes were counted in computing percent survival.

For comparison purposes, a fixed number of oviposited squares from each batch were also exposed for the same duration in the laboratory at room temperature to study their natural emergence rate. The weevil emergence values obtained in the laboratory were considered as 100% and the actual weevil emergence values obtained in the field were adjusted to this. This was not done for 1971.

Boll Rot:

Boll rot was reported as pounds of lint cotton lost per acre due to boll rot. Just prior to first harvest, 20 feet on one inside row of each plot at both locations was marked off and the number of rotten bolls at each picking was counted. Only those bolls that were so deteriorated that, in the opinion of the author, they would not have been picked by a mechanical picker were counted. They included both thoroughly decayed and 'tight-locked' bolls.

The total number of rotten bolls per acre was estimated by multiplying the number of rotten bolls per 20 feet with a conversion factor. This was then multiplied by the respective average boll weight and lint percentage to obtain the amount of cotton lost. Percent boll rot was calculated by dividing pounds of rotten lint by theoretical yield (harvested lint yield + rotten lint) x 100.

Plant Height:

Ten plants were selected at random from the two center rows for plant height measurements at Baton Rouge only. The plant height was measured from the ground to the tip of the main stem. The measurements were taken in 1971, 1972, and 1973.

Yield:

Harvesting, at both locations, was done by hand picking the fully open and fluffy bolls from a 20-ft. section from one of the two center rows. Picking was done at about weekly intervals, and weighed. The total seed cotton weight per 20-ft. (of each plot) was converted into pounds of lint per acre by multiplying it with a conversion factor and lint percentage.

In 1972 and 1973 two 20-ft. sections of the two center rows were harvested for yield purposes at Baton Rouge. But, the yield from only one row (the row from which boll rot data were also obtained) was considered in the statistical analysis. At St. Joseph, only one of the two center rows (20-ft. section) was harvested for yield purposes in all three years. Also, the intervals between successive pickings were longer than at Baton Rouge. The acre conversion factor used for both locations was 653.4.

Earliness:

Earliness is expressed as the percentage of the total crop harvested at the first picking. This was obtained by dividing the weight of seed cotton harvested at first picking by the total weight of seed cotton harvested (of all pickings) x 100.

A more detailed study of earliness was conducted at Baton Rouge only. Pickings were made at about weekly intervals. The percentage of crop harvested by dates was obtained by dividing the accumulated amount of cotton harvested at each date by the total cotton harvested. With this information, it could be shown, in days, how the leaf shapes differed from each other in earliness had they been harvested when approximately 70% of the crop of each was open.

Average Boll Weight:

A 50-boll sample was collected from each plot and weighed to the nearest gram. The samples were collected at the time of second picking at Baton Rouge, and at the time of first picking at St. Joseph. Average boll weight was computed by dividing the total weight of the 50-boll sample by 50.

Lint Percentage:

All the pickings of seed cotton for each plot were bulked and ginned after blending with a mechanical blender. The seed weights and lint weights were recorded for each plot and lint percentage was computed by the equation:

$$\frac{\text{Weight of lint}}{\text{Weight of seed + lint}} \times 100$$

Fiber Properties:

A 20 g sample was pulled from the lint of each plot (composite of all picking dates) and sent to the Louisiana State University Cotton Testing Laboratory. Measurements for fiber length, fiber strength, and fiber fineness were made under control led environmental conditions in accordance with the American Society for Testing and Materials Standards.

Fiber length at both 50% and 2.5% span length were determined by a photo-electric Model 230 Digital Fibrograph. The 50% span length is defined as the distance in inches from the clamps to where 50% of the fibers extend. The 2.5% span length is the distance in inches from the clamps to where 2.5% of the fibers extend. The 2.5% span length closely approximates the value of hand stapling. Fiber length uniformity ratio was determined by the formula: $\frac{\text{50\% span length}}{\text{2.5\% span length}} \times 100$

Fiber strength was determined on a Pressley Strength Tester at 1/8 inch gauge. The fiber strength is expressed as grams per tex - a standard unit for expressing fiber strength.

Fiber fineness was measured by a high speed automatic Micronaire instrument. Two determinations were made for each sample, but when these values did not fall within the $\pm$ 0.2 tolerence limit, a third determination was made and the average of the two closest values were taken.

Statistical Methods Used:

All of the data were subjected to the appropriate analysis of variance. Locations and years were analyzed separately and combined. The F test was used to determine significant mean square values and the Duncan's New Multiple Range test was used to indicate significantly different means at the 5% level of probability. The soil surface temperature and boll weevil survival data were also subjected to regression analysis.

RESULTS AND DISCUSSION

The objectives of this research project were to study the effects of row types and leaf shapes on plant microclimate, boll weevil survival, boll rot and other important agronomic characters of upland cotton. The F values for the different expressions of soil surface temperatures and percent boll weevil survival are presented in Table 1.

For the different expressions of soil surface temperatures (1972, 1973) and percent boll weevil survival (1971, 1972, 1973), the statistical analysis of the data of each batch was done seperately. Combined analysis for the batches or years was not done because of the batch and climatic interactions. Covariance analysis was performed to study the relationship between soil surface temperatures and percent boll weevil survival. Statistical analysis of the data of boll rot and other agronomic characters was performed for each location and for combined locations.

Greater emphasis was placed on the interpretation of the effects of such sources of variation as row types and leaf shapes and the interaction between them while discussing boll rot and other agronomic characters. First order interactions such as locations x treatments and years x treatments were given lesser emphasis. The second and third order interactions involving years and locations were given little emphasis because of the difficulties in interpreting them.

Table 1. Calculated F values for percent boll weevil survival and the different expressions of soil surface temperature, at Baton Rouge, La., 1972 and 1973.

Years and Batches	Percent Weevil Survival	F values: Soil surface temperatures expressed as: Avg. Daily Max. Temp. 1st Wk.	Avg. Daily Max. Temp. 2nd Wk.	Avg. Daily Max. Temp. Avg.	Degree-hours above 85 F 1st Wk.	Degree-hours above 85 F 2nd Wk.	Degree-hours above 85 F Total	Degree-hours above 90 F 1st Wk.	Degree-hours above 90 F 2nd Wk.	Degree-hours above 90 F Total	Degree-hours above 95 F 1st Wk.	Degree-hours above 95 F 2nd Wk.	Degree-hours above 95 F Total
1972													
1	24.44**	9.63**	9.43**	10.47**	11.64**	1.00	11.36**	9.07**	0.00	9.52**	4.08	0.00	4.08
2	0.13	9.43**	9.15**	15.00**	1.00	0.76	0.85	0.00	0.00	0.00	0.00	0.00	0.00
3	0.29	9.15**	2.87	5.50*	0.76	2.79	3.91	0.00	1.39	1.39	0.00	0.00	0.00
4	7.45*	2.87	23.69**	6.97*	2.79	16.07**	6.66*	1.39	4.14*	2.26	0.00	0.00	0.00
5	0.21	23.69**	24.58**	38.77**	16.07**	19.61**	22.28**	4.14*	13.07**	12.92**	0.00	0.00	0.00
6	3.75	24.58**	17.35**	24.86**	19.61**	51.04**	41.46**	13.07**	45.16**	38.44**	6.66*	43.11**	34.00**
7	8.99**	17.35**	41.09**	54.85**	51.04**	28.60**	48.52**	45.16**	11.52**	30.56**	43.11**	6.08*	26.21**
8	0.19	41.09**	16.13**	29.82**	28.60**	14.85**	26.39**	11.52**	8.70**	16.21**	6.08*	4.96*	8.31**
9	39.36**	16.13**	7.05*	11.55**	14.85**	12.27**	14.29**	8.70**	8.82**	9.94**	4.96*	7.10*	7.60**
1973													
1	0.21	0.38	2.10	1.12	0.62	0.51	0.31	1.00	0.66	0.52	0.00	0.00	0.00
2	2.57	2.10	14.38**	9.50**	0.51	2.22	1.61	0.66	2.29	0.84	0.00	0.00	0.00
3	0.78	14.38**	11.89**	15.94**	2.22	2.77	2.89	2.29	1.16	1.19	0.00	0.62	0.62
4	2.40	11.89**	16.97**	28.08**	2.77	8.16**	9.51**	1.16	5.72*	5.44*	0.62	3.35	2.42
5	3.52	16.97**	17.64**	20.92**	8.16**	6.37*	2.86	5.72*	4.73*	6.70*	3.35	2.84	3.86
6	2.49	17.64**	13.63**	27.88**	6.37*	5.40*	7.10*	4.73*	4.55*	6.26*	2.86	0.71	2.31

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

Soil Surface Temperatures

The average daily maximum soil surface temperatures for 1971, 1972 and 1973 are respectively presented in Tables 2, 2a, 3 and 4. Soil surface temperatures, expressed as total number of degree-hours above 85, 90 and 95 F, for the first week, second week and two week periods, during each batch period are presented in Tables 5, 7 and 9, respectively, for 1972 and in Tables 6, 8 and 10, respectively, for 1973.

Super okra leaf canopy almost always registered higher mean daily maximum temperatures and higher total number of degree-hours above 85, 90 and 95 F than okra. Okra, in turn, generally registered higher temperature values than normal. As an average of all batches of 1972 and 1973, normal leaf canopy registered 30.4, 7.5 and 2.3 degree-hours above 85, 90 and 95 F, respectively. Super okra and okra leaf canopies, respectively, had 8.6 and 3.3 times more degree-hours above 85 F, 20 and 6 times more degree-hours above 90 F and 28 and 7 times more degree-hours above 95 F than normal. The no canopy treatment was always very much higher than super okra and had an average of 1688.4, 1244.6 and 876.3 degree-hours above 85, 90 and 95 F, respectively.

Average daily maximum soil surface temperature:

In 1971, the average daily maximum temperatures were recorded for the three leaf shapes under solid and skip-row plantings and on both sides (east and west) of the test rows. The data were collected only for five days in a week.

The average daily maximum temperatures for those 5-day periods (Tables 2 and 2a) showed that the soil surface temperatures were slightly higher on the west side of the row than on the east side. This may have been because of the angle of incidence of sun rays on the soil surface. It was also found that when the crop was young the differences between the east and west side temperatures were larger but as the plants grew taller the differences were not appreciable.

There was very little difference in the average daily maximum soil surface temperatures of solid and skip rows. But soil surface temperatures under the leaf shapes varied appreciably. As an average of the season and in every batch individually, super okra leaf canopy had higher average daily maximum soil surface temperatures than okra and normal leaf canopies. Okra leaf had higher average daily maximum soil surface temperatures than normal leaf. The overall average daily maximum soil surface temperatures were 87.0, 88.9 and 91.9 F under normal, okra and super okra leaf canopies, respectively.

In 1972, as an average of all batches, super okra had the highest mean daily maximum temperatures (Table 3) among the

Table 2. Average daily maximum soil surface temperature (degrees Farenheit) as affected by row type (east side) and canopy type at Baton Rouge, La., 1971.

Row type and Canopy type	Dates 7/14* to 7/18	7/19 to 7/23	7/26 to 7/30	8/2 to 8/6	8/9* to 8/13	8/16 to 8/20	8/23 to 8/27	8/30* to 9/3	Average
Solid									
Super Okra	98.8	90.6	82.9	84.5	89.6	94.1	96.4	94.9	91.5
Okra	96.5	89.0	81.6	82.5	86.3	89.8	92.0	90.6	88.5
Normal	96.0	88.5	80.9	81.6	85.4	86.3	88.6	87.2	86.1
Average	97.1	89.4	81.8	82.9	87.1	90.1	92.3	90.9	88.7
Skip									
Super Okra	100.0	90.8	82.9	83.6	89.2	93.4	94.0	95.6	91.2
Okra	97.3	89.6	81.6	82.7	87.2	90.0	91.9	91.4	89.0
Normal	96.5	89.0	81.4	81.6	85.5	87.2	88.8	86.8	87.1
Average	97.9	89.8	82.0	82.6	87.3	90.2	91.6	91.3	89.1
Average of row types									
Super Okra	99.4	90.7	82.9	84.1	89.4	93.8	95.2	95.3	91.4
Okra	96.9	89.3	81.6	82.6	86.8	89.9	92.0	91.0	88.8
Normal	96.3	88.8	81.2	81.6	85.5	86.8	88.7	87.0	86.6
Average	97.5	89.6	81.9	82.8	87.2	90.2	92.0	91.1	88.9

* Averages are based on 4-day data instead of 5-day data, for these periods.

Table 2a. Average daily maximum soil surface temperature (degrees Farenheit) as affected by row type (west side) and canopy type at Baton Rouge, La., 1971.

Row type and Canopy type	Dates 7/14* to 7/18	7/19 to 7/23	7/26 to 7/30	8/2 to 8/6	8/9* to 8/13	8/16 to 8/20	8/23 to 8/27	8/30* to 9/3	Average
Solid									
Super okra	102.4	94.9	82.1	83.8	89.4	94.1	97.5	96.0	92.5
Okra	98.0	91.7	81.0	81.9	86.4	89.0	91.3	90.0	88.7
Normal	99.0	91.2	80.7	81.4	85.2	86.1	88.0	87.3	87.4
Average	99.8	92.6	81.3	82.4	87.0	89.7	92.3	91.1	89.5
Skip									
Super Okra	103.1	93.5	82.0	83.0	90.1	93.9	95.1	95.1	92.0
Okra	99.3	92.5	81.4	81.7	86.6	89.6	92.1	89.8	89.1
Normal	97.4	90.0	80.7	80.9	85.6	87.2	89.4	86.7	87.2
Average	99.7	92.0	81.4	81.9	87.4	90.2	92.2	90.5	89.4
Average of row types									
Super Okra	102.8	94.2	82.1	83.4	89.8	94.0	96.3	95.6	92.3
Okra	98.7	92.1	81.2	81.8	86.5	89.3	91.7	89.9	88.9
Normal	98.2	91.1	80.7	81.2	85.4	86.7	88.7	87.0	87.3
Average	99.9	92.3	81.4	82.2	87.2	90.0	92.3	90.8	89.5

* Averages are based on 4-day data instead of 5-day data, for these periods.

Table 3. Average daily maximum soil surface temperature (degrees Farenheit) as influenced by type of canopy at Baton Rouge, La., 1972.

Batch and Canopy	Degrees Farenheit		
	First week	Second week	2-wk Avg.
Batch 1			
Normal	88.8a*	78.3a	83.6a
Okra	91.2b	79.1a	85.1a
Super Okra	93.4b	80.5b	86.9b
No Canopy	119.2c	112.8c	116.0c
Batch 2			
Normal	78.3a	81.1a	79.7a
Okra	79.1a	82.3a	80.7b
Super Okra	80.5b	83.8b	82.2c
No Canopy	112.8c	107.5c	110.2d
Batch 3			
Normal	81.1a	81.1a	81.1a
Okra	82.3a	83.1ab	82.7a
Super Okra	83.8b	86.0b	84.9b
No Canopy	107.5c	112.6c	110.1c
Batch 4			
Normal	81.1a	78.0a	79.6a
Okra	83.1a	79.8b	81.4a
Super Okra	86.0b	82.6c	84.3b
No Canopy	112.6c	107.5d	110.1c
Batch 5			
Normal	78.0a	82.0a	80.0a
Okra	79.8b	87.3b	83.6b
Super Okra	82.6c	93.8c	88.2c
No Canopy	107.5d	122.2d	114.8d
Batch 6			
Normal	82.0a	86.5a	84.3a
Okra	87.3b	94.4b	90.0b
Super Okra	93.8c	102.7c	98.2c
No Canopy	122.2d	122.9d	122.5d

Table 3. (contd.)

Batch and Canopy	Degrees Farenheit First week	Second week	2-wk Avg.
Batch 7			
Normal	86.5a	84.4a	85.5a
Okra	94.3b	89.7b	92.0b
Super Okra	102.7c	97.6c	100.1c
No Canopy	122.9d	121.7d	122.3d
Batch 8			
Normal	84.4a	85.6a	85.0a
Okra	89.7b	88.9a	89.3b
Super Okra	97.6c	98.2b	97.9c
No Canopy	121.7d	116.3c	119.0d
Batch 9			
Normal	85.6a	89.6a	87.6a
Okra	88.9a	95.8a	92.3a
Super Okra	98.2b	107.5b	102.9b
No Canopy	116.3c	120.2c	118.2c

* Means followed by a letter in common do not differ at the 5% level of probability.

three leaf shapes. The mean daily maximum temperatures were 82.8, 86.4, 92.1 and 115.9 F under normal, okra, super okra and no canopy, respectively. In every batch, the (2-week) average daily maximum temperatures were significantly higher under super okra than under okra or normal. Okra had a higher 2-week mean daily maximum temperatures than normal in every batch, but the differences were significant only in 5 out of 9 batches. The 2-week average daily maximum temperatures ranged from 79.6 to 87.6 F under normal leaf, from 80.7 to 92.3 F under okra leaf, from 82.2 to 102.9 F under super okra and from 110.1 to 122.5 F under the no canopy treatment.

The average daily maximum temperatures were higher during the first week than during the second week in the 1st, 2nd, 4th and 7th batches while the opposite was true in the 3rd, 5th, 6th and 9th batches. In the 8th batch, the average daily maximum temperatures were about the same in both weeks.

In 1973, super okra leaf again had higher 2-week mean daily maximum temperatures than okra, and okra had higher temperature values than normal leaf (Table 4). As an average of all batches, the 2-week mean daily maximum temperatures were 78.5, 80.4, 84.1 and 102.8 F under normal, okra, super okra and no canopy treatments, respectively. In the 1st and 2nd batches, the 2-week average daily maximum temperatures were quite low under the three

Table 4. Average daily maximum soil surface temperature (degrees Farenheit) as influenced by type of canopy at Baton Rouge, La., 1973.

Batch and Canopy	Degrees Farenheit		
	First week	Second week	2-wk Avg.
Batch 1			
Normal	79.0a*	75.3a	77.2a
Okra	79.3a	75.3a	77.3a
Super Okra	79.9a	77.1a	78.5a
No Canopy	94.8b	101.4b	98.1b
Batch 2			
Normal	75.3a	76.2a	75.7a
Okra	75.3a	76.4a	75.9a
Super Okra	77.1a	79.7b	78.4b
No Canopy	101.4b	100.8b	101.1b
Batch 3			
Normal	76.2a	79.1a	77.6a
Okra	76.4a	81.6a	79.0a
Super Okra	79.7b	87.2b	83.4b
No Canopy	100.8c	112.6c	106.7c
Batch 4			
Normal	79.1a	78.6a	78.9a
Okra	81.6a	83.2b	82.4b
Super Okra	87.2b	90.0c	88.6c
No Canopy	112.6c	112.1d	112.4d
Batch 5			
Normal	78.6a	80.2a	79.3a
Okra	83.2b	82.2a	82.7b
Super Okra	90.0c	85.7b	87.9c
No Canopy	112.2d	94.9c	103.5d
Batch 6			
Normal	80.0a	84.5a	82.3a
Okra	82.2a	87.5b	84.8b
Super Okra	85.7b	89.8c	87.7c
No Canopy	94.9c	95.0d	95.0d

* Means followed by a letter in common do not differ at the 5% level of probability.

three leaf canopies, all being below 80 F. The average daily maximum temperatures under the no canopy treatment were 98.1 F in the 1st batch and 101.1 F in the 2nd batch. In the rest of the batches, the 2-week average daily maximum temperatures were relatively higher under the three leaf canopies and no canopy. But the temperatures under the three leaf canopies never crossed 90 F. The 2-week average daily maximum temperatures ranged from 75.7 to 82.3 F under normal leaf, from 75.9 to 84.8 F under okra leaf, from 78.4 to 88.6 F under super okra leaf and from 95.0 to 112.4 F under no canopy treatment. Super okra leaf had significantly higher 2-week mean daily maximum temperatures than normal leaf in 5 out 6 batches while okra leaf had significantly higher mean daily maximum temperatures than normal leaf in 3 out of 6 batches.

In all batches, the average daily maximum temperatures of 1st and 2nd weeks were about the same except in the 3rd batch where daily maximum temperatures in the 2nd week were higher than in the 1st week, and in the 5th batch where daily maximum temperatures during the 1st week were higher than in the 2nd week.

Consistently, it was found that the difference between super okra and normal leaf canopies were much larger than those between okra and normal or super okra and okra leaf canopies.

<u>Degree-hours above 85 F</u>:

In 1972 (Table 5), as an average of all batches, super okra leaf canopy accumulated (358.4) 9 times and okra leaf canopy (141) accumulated 3.5 times more degree-hours than normal leaf canopy (38.2). The no canopy treatment accumulated 2067.5 degree-hours (5.8 times more than super okra).

In all batches except 2 and 3, super okra leaf registered significantly higher total degree-hours above 85 F than okra and normal leaf canopies. The okra leaf canopy accumulated more degree-hours than normal leaf canopy in every batch, but it was significantly higher than normal leaf in only 3 out of 9 batches. In batches 2, 3 and 4, very few degree-hours above 85 F accumulated under the three leaf canopies. The total number of degree-hours accumulated ranged from 5.5 to 777.9 under super okra, from 6.1 to 332.8 under okra and from 0.5 to 136.4 under normal leaf. The total degree-hours under no canopy treatment ranged from 1298.2 to 2778.4.

The weekly totals of degree-hours above 85 F, for each batch, in 1972, are presented in Table 5. The first week periods contributed more degree-hours than the second week periods of batches 1, 2, 4, 7 and 8, while the opposite was true in batches 3, 5, 6 and 9.

Only six batches were studied in 1973. As an average

Table 5. Soil surface temperature (degree-hours above 85 F) as influenced by type of canopy at Baton Rouge, La., 1972.

	Degree-hours above 85 F		
Batch and Canopy	First week	Second week	Total
Batch 1			
Normal	136.4a*	0.0a	136.4a
Okra	211.1a	0.9a	212.0a
Super Okra	311.1b	0.0a	311.1b
No Canopy	1640.8c	628.1b	2268.9c
Batch 2			
Normal	0.0a	1.9a	1.9a
Okra	0.9a	5.2a	6.1a
Super Okra	0.0a	5.5a	5.5a
No Canopy	728.1b	570.1b	1298.2b
Batch 3			
Normal	1.9a	0.5a	2.4a
Okra	5.3a	3.6a	8.9a
Super Okra	5.5a	19.3a	24.8a
No Canopy	570.1b	882.9b	1453.0b
Batch 4			
Normal	0.5a	0.0a	0.5a
Okra	3.6a	4.1a	7.7a
Super Okra	19.3a	12.8b	32.1b
No Canopy	882.9b	668.0c	1550.9c
Batch 5			
Normal	0.0a	1.2a	1.2a
Okra	4.1a	48.0a	52.1a
Super Okra	12.8b	169.7b	182.5b
No Canopy	668.0c	1419.5c	2087.5c
Batch 6			
Normal	1.2a	40.4a	41.6a
Okra	48.0a	186.6b	234.6b
Super Okra	169.7b	428.7c	598.4c
No Canopy	1419.5c	1358.9d	2778.4d

Table 5. (contd.)

Batch and Canopy	Degree-hours above 85 F First week	Second week	Total
Batch 7			
Normal	40.1a	10.7a	51.1a
Okra	186.6b	75.0a	261.6b
Super Okra	428.7c	288.0b	716.7c
No Canopy	1358.9d	1245.9c	2604.8d
Batch 8			
Normal	10.7a	20.4a	31.1a
Okra	75.0a	78.4a	153.4a
Super Okra	288.0b	286.1b	574.1b
No Canopy	1245.9c	1046.3c	2292.2c
Batch 9			
Normal	20.4a	57.0a	77.4a
Okra	78.4a	254.4b	332.8b
Super Okra	286.1b	493.8c	779.9c
No Canopy	1046.4c	1226.8d	2273.2d

* Means followed by a letter in common do not differ at the 5% level of probability.

Table 6. Soil surface temperature (degree-hours above 85 F) as influenced by type of canopy at Baton Rouge, La., 1973.

Batch and Canopy	Degree-hours above 85 F First week	Second week	Total
Batch 1			
Normal	0.6a*	0.0a	0.6a
Okra	1.5a	1.7a	3.2 a
Super Okra	0.0a	2.7a	2.7a
No Canopy	313.8b	562.4b	876.2b
Batch 2			
Normal	0.0a	0.7a	0.7a
Okra	1.7a	0.7a	2.4a
Super Okra	2.7a	2.7a	5.4a
No Canopy	562.4b	392.7b	955.1b
Batch 3			
Normal	0.7a	29.5a	30.2a
Okra	0.7a	9.4a	10.1a
Super Okra	2.7a	83.2a	85.9a
No Canopy	392.7b	935.0b	1327.7b
Batch 4			
Normal	29.5a	2.8a	32.3a
Okra	9.4a	32.8a	42.3a
Super Okra	83.2a	117.3b	200.6b
No Canopy	935.0b	825.6c	1760.6c
Batch 5			
Normal	2.8a	9.1a	11.9a
Okra	32.9a	33.5a	66.3a
Super Okra	117.3b	78.4b	195.7b
No Canopy	825.6c	355.3c	1180.9c
Batch 6			
Normal	9.1a	27.4a	36.5a
Okra	33.5a	59.0ab	92.5ab
Super Okra	78.4b	86.9b	165.3b
No Canopy	355.3c	262.9c	618.2c

* Means followed by a letter in common do not differ at the 5% level of probability.

of all batches (Table 6), super okra leaf canopy (61.9) accumulated 3.3 times and okra leaf canopy (36.1) accumulated 2 times more degree-hours than normal leaf canopy (18.7). The no canopy treatment accumulated an average of 1119.8 degree-hours (19 times more than super okra). In every batch super okra leaf canopy accumulated more degree-hours than normal but statistically significant differences were found only in batches 4, 5 and 6. Okra leaf canopy accumulated more degree-hours than normal in five batches, but the differences were not statistically significant. The three leaf canopies did not accumulate any appreciable number of degree-hours during the 1st, 2nd and third batches and the differences among the three leaf shapes were also not significant. The total number of degree-hours accumulated under the leaf canopies ranged from 2.7 to 200.6 under super okra, from 2.4 to 92.5 under okra and from 0.6 to 36.5 under normal leaf. The lowest number of degree-hours accumulated under the no canopy treatment during the sixth batch (618.2) which also was the wettest period (9.02 inches of rainfall). The highest number of degree-hours (1760.6) accumulated during the fourth batch which was the driest period (0.39 inches of rainfall) for the season.

<u>Degree-hours above 90 F</u>:

As an average of all batches in 1972 (Table 7), super

Table 7. Soil surface temperature (degree-hours above 90 F) as influenced by type of canopy at Baton Rouge, La., 1972.

Batch and Canopy	Degree-hours above 90 F		
	First week	Second week	Total
Batch 1			
Normal	21.0a*	0.0a	21.0a
Okra	66.0b	0.0a	55.0a
Super Okra	106.2b	0.0a	106.2b
No Canopy	1297.9c	493.2b	1791.1c
Batch 2			
Normal	0.0a	0.0a	0.0a
Okra	0.0a	0.0a	0.0a
Super Okra	0.0a	0.0a	0.0a
No Canopy	493.2b	346.3b	839.5b
Batch 3			
Normal	0.0a	1.6a	1.6a
Okra	0.0a	2.2a	2.2a
Super Okra	0.0a	9.2a	9.2a
No Canopy	346.3b	671.4b	1017.7b
Batch 4			
Normal	1.6a	0.0a	1.6a
Okra	2.2a	0.2a	2.4a
Super Okra	9.2a	2.0b	11.2a
No Canopy	671.4b	481.9c	1153.3b
Batch 5			
Normal	0.0a	0.0a	0.0a
Okra	0.2a	15.1a	15.3a
Super Okra	2.0b	58.8b	60.5b
No Canopy	481.9c	1120.4c	1602.4c
Batch 6			
Normal	0.0a	6.4a	6.4a
Okra	15.1a	89.6b	104.7b
Super Okra	58.8b	259.2c	318.0c
No Canopy	1120.4c	1075.4d	2196.0d

Table 7. (contd.)

Batch and Canopy	Degree-hours above 90 F First week	Second week	Total
Batch 7			
Normal	6.4a	1.4a	7.8a
Okra	89.6b	13.7a	103.3a
Super Okra	259.2c	136.7b	395.9b
No Canopy	1075.4d	965.1c	2040.5c
Batch 8			
Normal	1.4a	3.8a	5.2a
Okra	13.7a	19.8a	33.1a
Super Okra	136.7b	147.5b	284.2b
No Canopy	965.1c	772.9c	1738.0c
Batch 9			
Normal	3.8a	17.4a	21.2a
Okra	19.4a	137.5a	157.0a
Super Okra	147.5b	295.5b	442.9b
No Canopy	773.4c	935.1c	1708.6c

* Means followed by a letter in common do not differ at the 5% level of probability.

okra leaf canopy accumulated the highest number of degree-hours above 90 F (199.3) which was 28 times more than that under normal leaf canopy. Okra leaf canopy had the next highest number of degree-hours (57.8) which was 8 times more than that under normal. The no canopy treatment accumulated 1565.2 degree-hours which was 7.9 times more than that under super okra.

The three leaf canopies registered zero degree-hours in the second batch and very few degree-hours in batches 3 and 4. The differences among leaf shapes were not significant in these batches. In every batch (except batch 2) super okra accumulated more degree-hours than okra and again okra accumulated more degree-hours than normal. Super okra had significantly higher number of degree-hours than normal in 6 of 9 batches. Okra leaf was significantly higher than normal in only one batch. The total degree-hours under the three leaf shapes ranged from 0 to 442.9 under super okra, from 0 to 157.0 under okra and from 0 to 21.2 under normal leaf. The total degree-hours under no canopy treatment ranged from 839.5 to 2196.0.

In 1973 (Table 8), as an average of all batches, super okra leaf canopy registered the highest number of degree-hours above 90 F (51.5) which was 6.5 times more than that under normal leaf. Okra leaf was the next highest (16.0) which had twice the number of degree-hours than under normal leaf. The no canopy accumulated

Table 8. Soil surface temperature (degree-hours above 90 F) as influenced by type of canopy at Baton Rouge, La., 1973.

Batch and Canopy	Degree-hours above 90 F First week	Second week	Total
Batch 1			
Normal	0.0a*	0.0a	0.0a
Okra	0.3a	0.5a	0.9a
Super Okra	0.0a	1.4a	1.4a
No Canopy	132.1b	367.5b	499.6b
Batch 2			
Normal	0.0a	0.0a	0.0a
Okra	0.5a	0.0a	0.5a
Super Okra	1.4a	0.4a	1.8a
No Canopy	367.5b	257.6b	625.1b
Batch 3			
Normal	0.0a	18.5a	18.5a
Okra	0.0a	5.1a	5.1a
Super Okra	0.4a	36.7a	37.1a
No Canopy	257.6b	726.3b	983.9b
Batch 4			
Normal	22.2a	0.6a	22.8a
Okra	5.1a	16.4a	21.5a
Super Okra	36.7a	60.1b	96.8b
No Canopy	689.8b	588.4c	1278.3c
Batch 5			
Normal	0.6a	1.8a	2.4a
Okra	16.5a	17.3ab	33.8a
Super Okra	60.1b	41.1b	101.2b
No Canopy	588.4c	243.0c	831.4c
Batch 6			
Normal	1.5a	5.9a	7.5a
Okra	17.3ab	16.7ab	33.9ab
Super Okra	41.1b	29.4b	70.5b
No Canopy	243.0c	121.7c	364.7c

* Means followed by a letter in common do not differ at the 5% level of probability.

763.8 degree-hours which was 14.8 times more than that under super okra.

Normal and okra leaf shapes did not register appreciable number of degree-hours above 90 F in any of the batches. The figures ranged from 0 to 22.8 under normal leaf and from 0.5 to 33.9 under okra leaf. The super okra leaf did not accumulate significant number of degree-hours in the first three batches but had relatively high number of degree-hours in the 4th, 5th and 6th batches. The range was from 1.4 to 101.2. Okra leaf did not differ significantly from normal leaf in any of the batches. Super okra was significantly higher than normal in 3 out of 6 batches. Degree-hours that accumulated under the no canopy treatment ranged from 364.7 to 1278.3.

<u>Degree-hours above 95 F</u>:

In 1972 (Table 9), as an average of all batches, the super okra leaf accumulated the highest number of degree-hours (90.6) among the leaf shapes which was 113 times more than that under normal leaf. Okra leaf had much fewer degree-hours than super okra (20.9) which was 26 times more than that under normal leaf. The average number of degree-hours under normal leaf was only 0.8. The no canopy treatment accumulated an average of 1118.1 degree-hours (12.3 times more than that under super okra).

Table 9. Soil surface temperature (degree-hours above 95 F) as influenced by type of canopy at Baton Rouge, La., 1972.

Batch and Canopy	Degree-hours above 95 F First week	Second week	Total
Batch 1			
Normal	0.4a*	0.0a	0.4a
Okra	11.5a	0.0a	11.5a
Super Okra	20.5a	0.0a	20.5a
No Canopy	966.5b	318.2b	1284.7b
Batch 2			
Normal	0.0a	0.0a	0.0a
Okra	0.0a	0.0a	0.0a
Super Okra	0.0a	0.0a	0.0a
No Canopy	318.2b	216.0b	534.2b
Batch 3			
Normal	0.0a	0.0a	0.0a
Okra	0.0a	0.0a	0.0a
Super Okra	0.0a	0.0a	0.0a
No Canopy	216.0b	431.1b	647.1b
Batch 4			
Normal	0.0a	0.0a	0.0a
Okra	0.0a	0.0a	0.0a
Super Okra	0.0a	0.0a	0.0a
No Canopy	431.1b	324.9b	756.0b
Batch 5			
Normal	0.0a	0.0a	0.0a
Okra	0.0a	6.4a	6.4a
Super Okra	0.0a	18.6b	18.6b
No Canopy	324.9b	810.6c	1135.5c
Batch 6			
Normal	0.0a	0.0a	0.0a
Okra	0.4a	38.7b	45.1a
Super Okra	17.1b	154.9c	171.9b
No Canopy	810.6c	832.4d	1642.9c

Table 9. (contd.)

Batch and Canopy	Degree-hours above 95 F First week	Second week	Total
Batch 7			
Normal	0.0a	0.0a	0.0a
Okra	38.7b	5.8a	44.5a
Super Okra	154.9c	67.7b	222.6b
No Canopy	832.4d	704.3c	1536.6c
Batch 8			
Normal	0.0a	1.1a	1.1a
Okra	5.8a	2.7a	8.4a
Super Okra	67.7b	71.5b	139.2b
No Canopy	704.3c	563.7c	1268.0c
Batch 9			
Normal	1.1a	4.9a	6.0a
Okra	2.7a	69.3ab	72.0a
Super Okra	71.5b	171.0b	242.4b
No Canopy	563.7c	694.1c	1257.8c

* Means followed by a letter in common do not differ at the 5% level of probability.

None of the leaf shapes accumulated any degree-hours above 95 F in the 2nd, 3rd and 4th batches. The super okra leaf registered higher number of degree-hours than normal leaf in every batch except batches 2, 3 and 4, ranging from 0 to 242.4. Okra leaf had relatively fewer degree-hours but almost always more than normal leaf, ranging from 0 to 72.0. Normal leaf had almost no degree-hours above 95 F in 8 out of 9 batches. The highest number of degree-hours accumulated under normal leaf was 6.0 (batch 9). Super okra was significantly higher than normal in 5 out of 9 batches, but the differences between okra and normal were not significant in any batch.

In none of the batches in 1973 (Table 10) were there statistically significant differences among leaf shapes. Absolutely no degree-hours above 95 F were recorded by the three leaf shapes in the 1st and 2nd batches. In the other four batches, the degree-hours above 95 F under normal, okra and super okra ranged from 0.0 to 12.9, 2.0 to 20.2 and 17.0 to 55.9, respectively. The range for the same under no canopy treatment was from 217.4 to 942.3. As an average of all batches, the total number of degree-hours above 95 F were 4.6, 8.5, 25.5 and 513.4 under normal, okra, super okra and no canopy treatments, respectively.

Table 10. Soil surface temperature (degree-hours above 95 F) as influenced by type of canopy at Baton Rouge, La., 1973.

	Degree-hours above 95 F		
Batch and Canopy	First week	Second week	Total
Batch 1			
Normal	0.0a*	0.0a	0.0a
Okra	0.0a	0.0a	0.0a
Super Okra	0.0a	0.0a	0.0a
No Canopy	37.8b	229.3b	267.1b
Batch 2			
Normal	0.0a	0.0a	0.0a
Okra	0.0a	0.0a	0.0a
Super Okra	0.0a	0.0a	0.0a
No Canopy	229.3b	158.1b	387.4b
Batch 3			
Normal	0.0a	12.9a	12.9a
Okra	0.0a	2.0a	2.0a
Super Okra	0.0a	17.2a	17.2a
No Canopy	158.1b	541.9b	700.0b
Batch 4			
Normal	12.9a	0.0a	12.9b
Okra	2.0a	10.3a	12.2a
Super Okra	17.2a	29.6a	46.8a
No Canopy	541.9b	400.3b	942.3b
Batch 5			
Normal	0.0a	0.0a	0.0a
Okra	9.5a	10.7a	20.2a
Super Okra	29.6a	26.3a	55.9a
No Canopy	400.3b	166.2b	566.5b
Batch 6			
Normal	0.0a	2.0a	2.0a
Okra	10.7a	5.9a	16.7a
Super Okra	26.3a	6.6a	33.0a
No Canopy	166.2b	51.2b	217.4b

* Means followed by a letter in common do not differ at the 5% level of probability.

Light Penetration

The amount of sunlight penetration through the three leaf canopies, measured at the soil surface, in foot-candles, at different dates in 1972 and 1973, is presented in Table 11 and Fig. 1.

Data on sunlight penetration were collected from July 7 to August 19 on eight different dates in 1972 and from July 12 to August 22 on four different dates in 1973. The 1972 test was planted on April 25, and the 1973 test was planted on May 15.

For comparison purposes, the amount of sunlight penetration through normal leaf canopies was considered as 100%.

In 1972, okra had 63, 53, 42, 59, 83, 96, 278 and 157% more sunlight penetration than normal at the 73rd, 82nd, 88th, 94th, 99th, 106th, 108th and 116th day after planting, respectively. Super okra recorded 134, 165, 129, 174, 222, 266, 565 and 537% more sunlight penetration than normal on the same days. The data indicate that as the season progressed, the differences between leaf shapes also increased. This most probably was due to the fact that as the three leaf shapes approached the cut-out stage, leaf shedding was initiated. Okra and super okra were earlier in reaching the cut-out stage and also lost more of the foliage earlier than normal. Normal leaf also lost some foliage, and this is shown by the increasing amounts of sunlight penetration for this treatment as the season progressed. As an average of all dates in 1972, okra and

Table 11. Light penetration (foot-candles) as influenced by type of canopy at Baton Rouge, La., 1972 and 1973.

Years and Dates	Canopy			
	Normal	Okra	S. Okra	No Canopy
1972				
July 7	144c*	235b	337a	-@
July 16	98d	150c	250b	6414a
July 22	85d	121c	195b	6060a
July 28	97d	154c	266b	6190a
August 2	114d	209c	367b	6927a
August 9	156d	306c	571b	6793a
August 11	231d	870c	1535b	6117a
August 19	243d	624c	1548b	6148a
Average	153d	360c	688b	6078a
1973				
July 12	280d	392c	484b	5864a
July 27	230d	318c	462b	6086a
August 7	96c	130c	242b	6656a
August 22	150d	248c	506b	6376a
Average	189	272	424	6246
Overall Average	160	313	564	6330

* Means followed by a letter in common do not differ at the 5% level of probability.

@ Data for no canopy was not obtained.

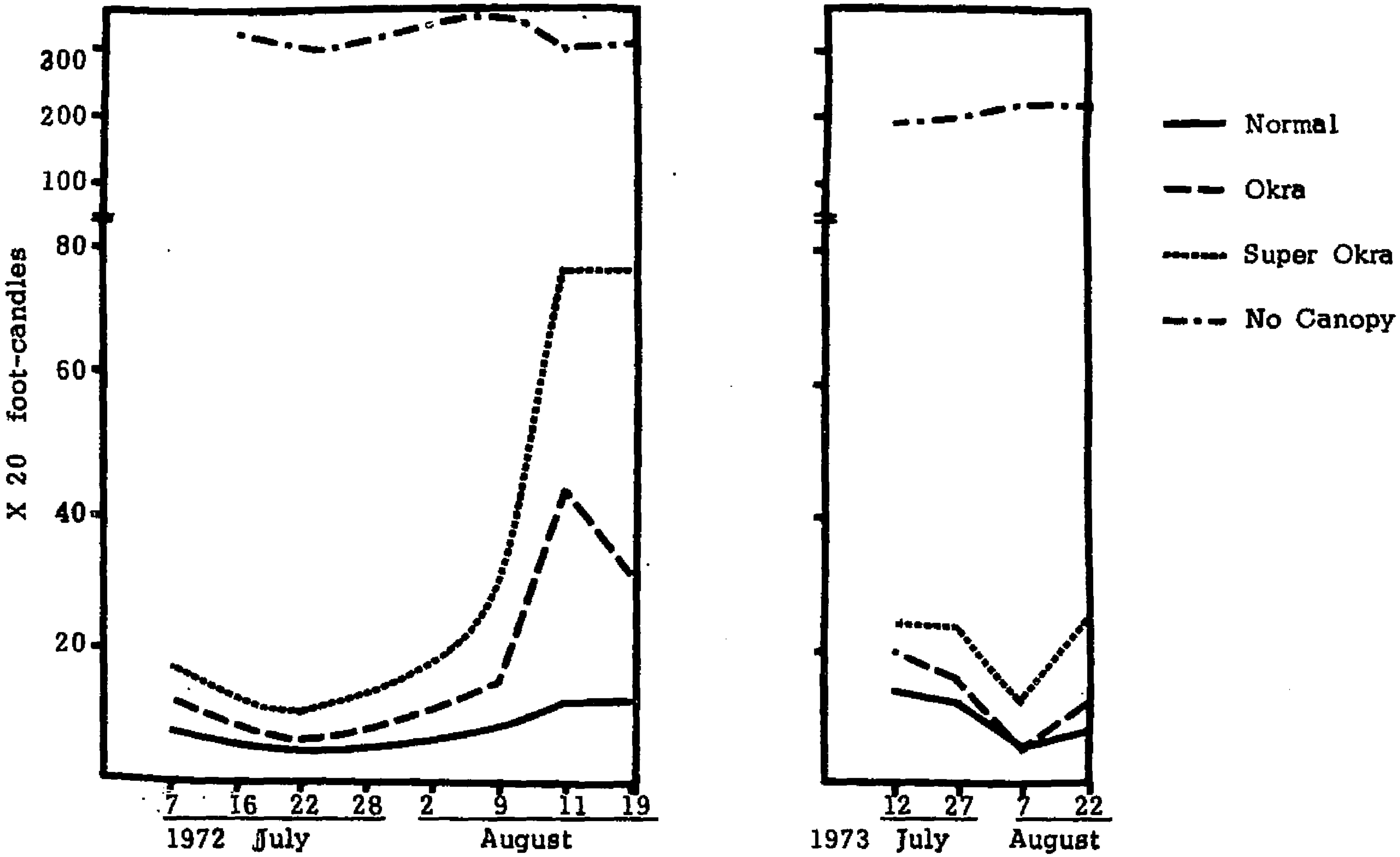

Fig. 1. Light penetration as influenced by type of canopy at Baton Rouge, La.

super okra leaf shapes recorded 135 and 450% more sunlight penetration than normal leaf. These figures may be somewhat inflated because the data included measurements after excessive leaf shedding. If the last two dates (8/11 and 8/19) were excluded from averages for the above reason, okra and super okra had 72 and 192% more sunlight penetration than normal. These figures may be more representative of the leaf shape averages. Nevertheless, it is important to know that after the cut-out stage, okra and super okra are much more open canopied than normal This could be very advantageous in promoting shorter maturity periods and in helping to reduce boll rot losses by increasing aeration. It is interesting to note that only 2.4, 5.6 and 10.7% of the total sunlight (no canopy) penetrated through the normal, okra and super okra leaf shape canopies, respectively, as an average of all dates in 1972. At each date and as an average of all dates in 1972, the three leaf shapes were significantly different from each other.

In 1973, data were obtained only on four dates. Okra recorded 40, 38, 35 and 65% and super okra recorded 73, 101, 153 and 237% more sunlight at the soil surface than normal leaf canopy on the 58th, 73rd, 84th and 99th day after planting. All three leaf shapes were highly significantly different from each other, except on the 84th day after planting. At this date, normal and okra did not differ from each other, but both were significantly lower than super okra.

Selecting and comparing only those dates in 1972 (7/7, 7/22 and 8/2) and in 1973 (7/27, 8/7 and 8/22) which indicated that measurements were made approximately on the same number of days after planting (73rd, 88th and 99th days in 1972, and 73rd, 84th and 99th days in 1973), showed that the differences between leaf shapes were about the same in both years. Okra leaf, for example, recorded 63, 42 and 83% more sunlight in 1972, and 40, 38 and 65% more sunlight in 1973, than normal leaf for the respective dates.

Increase in light penetration due to okra and super okra leaf shapes over normal leaf shape was expected. Major (1971) reported that as an average of all families and bract types at two locations in Louisiana, okra leaf increased light penetration by approximately 65% over that of normal. His was the first published report on actual measurements of light penetration comparing okra leaf with normal leaf canopies. This report is in agreement with the results of Major's study. Indirectly referring to light penetration were the reports of Jones and Andries (1967), Andries et al. (1969, 1970), Cook and Doyle (1927) and Brown and Cotton (1937). They referred to okra leaf, or to both okra and super okra leaf shapes as having substantially less leaf area than normal leaf type and observed, without quantifying it, that more sunlight penetrated the open canopies of okra and super okra leaf shapes than the more dense canopy of normal leaf.

This is the first published report on the actual measurements of light penetration under super okra leaf canopy.

Relative Humidity

Relative humidity (RH) expressed in absolute values for 1971, and in hours per day of 95% or above relative humidity for 1972 and 1973, is presented in Tables 12 and 13, respectively.

In 1971, due to non-availability of hygrothermographs, relative humidity was measured by a portable thermistor psychrometer. As an average of five dates of measurements, leaf shapes and row types (Table 12), it was found that the RH at the soil surface was 2.8% higher than at the 12-inch height (from soil surface) in the plant canopy. The RH in the skip-row was slightly lower than that under the solid-row, both at the soil surface and 12-inch level. It was also observed that the super okra canopy had the lowest RH values at both levels among the three leaf shapes. Okra leaf canopy had lower RH values than normal leaf canopy. But the differences in RH values among canopies were greater at the 12-inch level than at the soil surface level. The RH values at the soil surface level indicate that the soil surface under super okra leaf canopy may dry up faster than that under

Table 12. Percent relative humidity at three levels within the plant canopy as influenced by row type and leaf shape at Baton Rouge, La., 1971.

Row types and Leaf Shapes	Height levels (% RH) Soil-surface vs 12-in* surface	12-in.	12-in. vs 24-in.@ 12-in.	24-in.
Solid				
Normal	71.9	70.6	53.8	54.1
Okra	72.6	69.8	49.9	48.6
Super Okra	71.0	66.6	49.9	48.2
Average	71.8	69.0	51.2	50.3
Skip				
Normal	72.1	70.8	54.3	53.1
Okra	71.5	67.9	50.2	50.0
Super Okra	70.7	66.9	49.7	49.1
Average	71.4	68.5	51.4	50.4
Average of row types				
Normal	72.0	70.7	54.1	53.6
Okra	72.1	68.9	50.1	49.3
Super Okra	70.9	66.8	49.8	48.7
Overall Average	71.6	68.8	51.3	50.4

* Average of 5 dates of 6 replications each (8/20, 8/25, 8/26, 8/27, and 8/30).

@ Average of 2 dates of 6 replications each (9/13 and 9/14).

okra or normal.

Measurements were made on two dates to compare RH values at the 12-inch and 24-inch heights (from ground level) in the three leaf canopies under solid and skip row plantings. The data indicated that the RH values in the plant canopy were slightly lower at the 24-inch height than at the 12-inch height. There was no difference in the RH values of solid and skip rows. Again, super okra canopy had lower RH values than the okra and normal leaf canopies, and okra leaf had lower RH values than normal leaf canopy.

In 1972, RH data were obtained from July 21 to September 29. They are summarized in three unequal periods because of the manner in which the data were collected (Table 13). The first and third periods were recorded on weekly charts, while the second was recorded on daily charts.

The first period consisted of 17 days during peak flowering. Normal leaf had an average of 15 hours per day of 95% or above RH; this was 52 and 90 minutes per day longer than for okra and super okra, respectively. Differences were significant at the 5% level of probability. In the second period, consisting of 22 days during late flowering and early boll opening, normal leaf recorded 13.1 hours per day of 95% or above RH. This was 20 and 46 minutes per day longer than for okra and super okra, respectively.

Table 13. Relative humidity (RH), expressed as mean duration of RH of 95% or above, as affected by type of canopy at Baton Rouge, La., 1972 and 1973.

Years and Dates	Duration, hours per day			
	Canopy			
	Normal	Okra	Super Okra	Average
1972				
7/21 to 8/6	15.0a*	14.2b	13.5c	14.2
8/7 to 8/28	13.1a	12.8b	12.4c	12.8
8/29 to 9/29	13.8a	13.7a	13.3b	13.6
Season's Avg. (weighted)	13.9	13.5	13.0	13.5
1973				
8/7 to 9/3	14.5	14.3	13.6	14.1
9/11 to 10/2	15.3	14.8	14.5	14.9
10/3 to 10/30	13.0	13.0	12.7	12.9
Season's Avg. (weighted)	14.2a	14.0a	13.5b	14.0

* Means followed by a letter in common do not differ at the 5% level of probability.

These differences were also statistically significant at the 5% level. In the third period, consisting of 32 days during boll opening and harvesting, normal averaged 13.8 hours per day of the designated level of RH. This was 5 and 48 minutes per day longer than okra and super okra, respectively. Differences between normal and okra were not statistically significant, but super okra was significantly different from normal and okra at the 5% level of probability.

In 1973, the data on relative humidity was recorded on weekly charts during August, September and October (Table 13). As an average of all dates, normal leaf had 14.2 hours per day of RH of above 95% or above. This was 12 and 42 minutes longer than in okra and super okra, respectively. Only normal and super okra leaf canopies were significantly different from each other. Normal had 14.5 hours per day of the stated RH in August. This was 12 and 54 minutes per day longer than in okra and super okra, respectively. In September, normal had 15.3 hours per day of the designated RH; this was 30 and 48 minutes longer than in okra and super okra, respectively. In October, normal and okra had 13.0 hours per day with RH of 95% or above; this was 18 minutes longer than in super okra.

The highest average duration of 95% or above RH was 14.9 hours per day. This occurred from September 11 to October 2, when the total rainfall received was also the most (4.29 inches) compared to other months. In August (August 7 to September 3), the duration for the same RH level was 14.1 hours per day, and in October (October 3 to October 30), it was 12.9 hours. The total rainfall received during these periods was 3.16 and 2.99 inches, respectively.

The data indicate that the open canopies of okra and super okra leaf have somewhat shorter durations of extremely high humidity than normal leaf cotton. And, this would be expected to facilitate a more rapid drying out of the soil surface and plant parts than the dense canopy of normal cotton. That more open type plant canopies result in shorter durations of 95% or above relative humidity was also reported by Ranney et al. (1971). They had observed that opening up the plant canopy by bottom defoliation or full defoliation resulted in 2 to 3 hours shorter durations of relative humidity of 95% or above during 5-day periods.

Boll Weevil Survival

Percent survival of boll weevils from oviposited squares as influenced by type of canopy at Baton Rouge is presented in Tables 14 and 14a for 1971, in Table 15 and Fig. 2 for 1972, and in Table 16 and Fig. 3 for 1973.

There were 11 batches of weevil punctured squares under study in 1971. Only 25 weevil oviposited squares were exposed in each batch. The no canopy treatment was not included in 1971, but solid and skip-row types were included. The oviposited squares were spread on the east and west side of the row.

The data (Tables 14, 14a) indicate that the side of the row (east or west) did have some influence on the weevil survival. The percent weevil survival was lower on the west side of the row compared to the east side of the same row. It may be mentioned that the daily average maximum soil surface temperatures were also found to be higher on the west side than on the east side. The influence of the side of row for both weevil survival and daily maximum temperatures was more pronounced in the solid-row planting than in the skip-row planting.

As an average of all batches in 1971, the percent weevil survival under solid-row was 54.3 and under skip-row was 57.4. The statistical analysis of individual batch data showed that there was no significant difference due to row type in 10 out of the 11 batches.

It was also observed that super okra and okra leaf canopies reduced the weevil survival, on an average, by 12 and 5% over normal leaf canopy, respectively. But in only one batch was there a significant difference between super okra and normal.

The skip-row treatment was excluded from weevil studies

Table 14. Percent boll weevil survival as influenced by row type (east side) and canopy type at Baton Rouge, La., 1971.

Row type and Canopy type	Batch Numbers 1	2	3	4	5	6	
	Dates						
	7/13* to 7/20	7/23 to 8/5	7/29 to 8/11	8/5 to 8/19	8/12 to 8/26	8/18 to 9/1	Avg.**
Solid							
Normal	59.8	50.0	74.0	69.5	44.3	57.3	61.0
Okra	70.8	41.8	65.8	61.5	37.3	63.2	59.7
Super Okra	49.8	49.0	74.7	61.5	29.3	43.8	51.8
Average	60.2	46.9	71.5	64.2	37.0	54.8	57.5
Skip							
Normal	60.2	55.3	75.2	68.5	34.5	64.3	60.5
Okra	61.3	49.8	75.2	58.8	33.5	57.8	57.3
Super Okra	57.8	51.3	68.7	62.5	39.2	53.7	56.4
Average	59.8	51.3	73.0	63.3	35.7	58.6	58.1
Average of Row types							
Normal	60.0	52.7	74.6	69.0	39.4	60.8	60.8
Okra	66.1	45.8	70.5	60.2	35.4	60.5	58.5
Super Okra	53.8	48.9	71.7	62.0	34.3	41.8	54.1

* This batch was exposed for one week instead of two weeks.

** Batch 2 was not considered in computing the average as there was no corresponding batch for west side of the row.

Table 14a. Percent boll weevil survival as influenced by row type (west side) and canopy type at Baton Rouge, La., 1971.

	Batch Numbers					
	1	2	3	4	5	
	Dates					
Row type and Canopy type	7/14* to 7/21	7/27 to 8/10	8/3 to 8/17	8/10 to 8/24	8/17 to 8/31	Avg.
Solid						
Normal	49.7	74.0	65.2	38.8	58.7	57.3
Okra	42.7	72.5	64.5	41.3	53.0	54.8
Super Okra	25.8	59.0	63.5	34.3	44.7	45.5
Average	39.4	68.5	64.4	38.2	52.1a 1/	52.5
Skip						
Normal	54.7	74.7	63.2	41.8	69.0	60.7
Okra	43.3	66.2	68.8	40.3	67.5	57.2
Super Okra	39.3	69.8	64.3	39.0	67.3	55.9
Average	45.8	70.2	65.4	40.4	67.9b	57.9
Average of Row types						
Normal	52.2b	74.3	64.2	40.3	63.8	58.9
Okra	43.0ab	69.3	66.7	40.8	60.3	56.0
Super Okra	32.6a	64.4	63.9	36.7	56.0	50.7

* This batch was exposed for one week instead of two weeks.

1/ Means followed by a letter in common do not differ at the 5% level of probability.

in 1972 and 1973 as it was felt necessary to increase the number of oviposited squares to be exposed from 25 to 50 per plot per batch. It would have been difficult to obtain the required number of oviposited squares for both solid and skip-row treatments on the same date. Furthermore, there was no marked effect of row type on weevil survival indicated in 1971.

In 1972 and 1973 a reference sample of 300 boll weevil oviposited squares (from the collected squares for each batch) was also run, for every batch, at room temperature for the same period as in the field, and the boll weevil survival percentage was determined. It was found that this reference sample always had a higher weevil survival than under any leaf shape canopy in the field. The survival data of this sample was considered as 100% and the field data of each batch was adjusted to the corresponding reference sample data for the purpose of making all batches comparable. Only these values are used in the discussion.

The no canopy treatment was added in 1972 and 1973 seasons for a study of comparison with leaf shape canopies.

The most consistent feature of these results was that the percentage survival of boll weevils was lowest under no canopy compared to any of the three leaf type canopies. This was observed in every batch, in both years and during both dry and wet periods. As an average of all 15 batches (both years), percent weevil survival was 13.9 under no canopy, 89.6 under normal leaf, 84.5 under okra leaf and 78.8 under super okra leaf canopies. Super okra and okra leaf shapes, respectively, caused 12.1 and 5.7% reduction in weevil survival over normal leaf shape.

In only 4 out of the 9 batches in 1972 were there any statistically significant differences detected among leaf shapes (Table 15 and Fig. 2). Super okra had significantly lower survival rate than normal leaf shape in 3 out of the 4 batches. In the fourth batch the reverse was true; super okra had significantly higher survival rate than normal leaf canopy.

In the first batch, okra and super okra leaf canopies registered 22 and 41% reduction in weevil survival over normal leaf canopy. The weevil survival under no canopy was reduced by 98% over normal. In the 7th and 9th batches, respectively, the weevil survival rate was reduced by 16 and 27% under okra, 47 and 68% under super okra and by 100 and 95% under no canopy compared with normal leaf canopy. All the three leaf shapes significantly differed from each other in the above three batches. The calculated 'F' value for the sixth batch approached but did not quite equal significance. Okra and super okraleaf shapes reduced the weevil survival in the sixth batch by 15 and 23% over normal, respectively. As an average of only these batches (1st, 6th, 7th and 9th), the weevil survival was reduced by 20 and 44% of normal under the okra and super okra leaf canopies, respectively.

Table 15. Percent boll weevil survival as influenced by type of canopy at Baton Rouge, La., 1972.

Batch and Canopy	Dates of exposure	% boll weevil survival: actual values	% boll weevil survival: % of laboratory survival@
Batch 1			
Normal		57.0a*	83.8
Okra	6/29	40.4b	65.3
Super Okra	to	33.4c	49.1
No Canopy	7/13	1.3d	1.9
Reference Sample (lab.)@		68.0	-
Batch 2			
Normal		72.8a	98.4
Okra	7/6	70.5a	95.3
Super Okra	to	73.5a	99.3
No Canopy	7/20	39.0b	52.7
Reference Sample (lab.)		74.0	-
Batch 3			
Normal		70.0a	80.8
Okra	7/13	71.0a	82.0
Super Okra	to	73.9a	85.3
No Canopy	7/27	15.2b	17.6
Reference Sample (lab.)		86.6	-
Batch 4			
Normal		61.0b	77.5
Okra	7/20	66.0ab	83.9
Super Okra	to	73.3a	93.1
No Canopy	8/3	21.5c	27.3
Reference Sample (lab.)		78.7	-
Batch 5			
Normal		60.5a	83.6
Okra	7/27	57.7a	79.7
Super Okra	to	60.6a	83.7
No Canopy	8/10	5.0b	6.9
Reference Sample (lab.)		72.4	-

Table 15. (contd.)

Batch and Canopy	Dates of exposure	% boll weevil survival: actual values	% boll weevil survival: % of laboratory survival
Batch 6			
Normal		54.2a	96.7
Okra	8/3	45.7a	81.8
Super Okra	to	41.4a	74.1
No Canopy	8/17	3.0b	5.4
Reference Sample (lab.)		55.9	-
Batch 7			
Normal		70.2a	98.5
Okra	8/10	59.0b	82.8
Super Okra	to	37.2c	52.2
No Canopy	8/24	0.0d	0.0
Reference Sample (lab.)		71.3	-
Batch 8			
Normal		47.5a	99.4
Okra	8/17	44.9a	93.9
Super Okra	to	47.0a	98.3
No Canopy	8/31	2.0b	4.2
Reference Sample (lab.)		47.8	-
Batch 9			
Normal		57.9a	82.4
Okra	8/24	42.2b	60.0
Super Okra	to	18.8c	26.7
No Canopy	9/7	2.7d	3.8
Reference Sample		70.3	-
Average of Batches			
Normal		61.2	89.0
Okra		55.7	80.5
Super Okra		51.0	73.5
No Canopy		10.0	13.3
Reference Sample (lab.)		69.4	-

@ Both are same; exposed at room temperatures.

* Means followed by a letter in common do not differ at the 5% level of probability.

Table 16. Percent boll weevil survival as influenced by type of canopy at Baton Rouge, La., 1973.

Batch and Canopy	Dates of exposure	% boll weevil survival actual values	% of laboratory survival@
Batch 1			
Normal		58.7a*	90.0
Okra	7/26	63.1a	96.8
Super Okra	to	61.2a	93.9
No Canopy	8/9	3.4b	5.2
Reference Sample (lab.)@		65.2	-
Batch 2			
Normal		78.9a	92.8
Okra	8/2	75.3a	88.6
Super Okra	to	83.0a	97.7
No Canopy	8/16	3.0b	3.5
Reference Sample (lab.)		85.0	-
Batch 3			
Normal		60.7a	80.9
Okra	8/9	65.0a	86.7
Super Okra	to	60.1a	80.1
No Canopy	8/23	10.6b	14.1
Reference Sample (lab.)		75.0	-
Batch 4			
Normal		64.9a	88.5
Okra	8/17	62.9a	85.8
Super Okra	to	59.2a	80.8
No Canopy	8/31	2.5b	3.4
Reference Sample (lab.)		73.3	-
Batch 5			
Normal		79.7a	99.6
Okra	8/23	76.0a	95.0
Super Okra	to	66.5a	83.1
No Canopy	9/6	0.7b	0.9
Reference Sample (lab.)		80.0	-

Table 16. (contd.)

Batch and Canopy	Dates of exposure	% boll weevil survival: actual values	% boll weevil survival: % of laboratory survival
Batch 6			
Normal		65.3a	90.7
Okra	8/31	64.3a	89.3
Super Okra	to	61.3a	85.1
No Canopy	9/13	44.2b	61.4
Reference Sample		72.0	-
Average of Batches			
Normal		68.0	90.4
Okra		67.8	90.3
Super Okra		65.2	86.8
No Canopy		10.7	14.8

@ Both are same; exposed at room temperatures.

* Means followed by a letter in common do not differ at the 5% level of probability.

It was quite interesting to note a reversal (statistically significant) in the above trend in the fourth batch. Super okra had the highest survival rate followed by okra and normal. Weevil survival rate was increased by 8 and 20% under okra and super okra over that of normal. The difference between normal and super okra only was significant.

There were almost no differences among leaf shapes in the other four batches (2nd, 3rd, 5th and 8th). The survival rate for the reference sample (laboratory) in the eighth batch was very low. This was evidently reflected in the low weevil survival for all canopy treatments in that particular batch. There is no explanation for this, except that the squares collected for this batch were from a different field (due to scarcity) than the squares used for all other batches.

In 1972, as an average of nine batches, super okra had the lowest weevil survival among the three leaf canopies (73.5%) followed by okra (80.5%) and normal (89.0%). Super okra and okra leaf canopies resulted in an average reduction of 16.7 and 9.4% in weevil survival over normal, respectively.

In 1973, none of the six batches showed significant differences among leaf shapes (Table 16 and Fig. 3). In some batches (1st and 2nd) super okra had slightly higher survival rate than either okra or normal; while in others, it had lower survival rate than okra and normal. In the fifth batch the percent weevil survival under super okra was 83.1%, a lower percentage survival than normal (99.6%) and okra (95.0%). These differences were not statistically significant. The 1973 average weevil survival was 90.4% under normal leaf, 90.3% under okra leaf and 86.8% under super okra leaf canopies. The super okra and okra leaf canopies caused an average reduction of 4.1 and 0.1% over normal, respectively. The 1973 season was an especially wet one which did not let the soil surface temperature rise high enough under the plant canopies to cause appreciable mortality. Overall boll weevil survival under the three plant canopies was appreciably lower in 1972 (81%) than in 1973 (91.9%).

The number of actual dead immature boll weevil stages observed under the four canopies in 1972 and 1973 are presented in Tables 17 and 18, respectively. The percentage of dead weevils was calculated by the formula:

$$\frac{\text{number of dead weevils (actually identified)}}{\text{number of live + dead (actually identified)}} \times 100.$$

The apparent dead forms that could not be identified were not included in these averages. These data were not subjected to a statistical analysis.

As an average of nine batches in 1972, the percentage of dead weevils (identified) was 4.5, 6.2, 13.1 and 59.4 under

Table 17. Mortality (identified) in immature boll weevil stages as affected by type of canopy at Baton Rouge, La., 1972.

Batch and Canopy	Observed Dead Weevils (no.)				Live Weevils (no.)	Percent * Dead Weevils
	Larvae	Pupae	Adults	Total		
Batch 1						
Normal	1	7	3	11	168	6.2
Okra	1	5	2	8	131	5.8
Super Okra	5	7	3	15	97	13.4
No Canopy	1	2	0	2	4	33.3
Batch 2						
Normal	0	2	4	6	212	2.8
Okra	2	2	0	4	205	2.0
Super Okra	0	1	0	1	204	0.5
No Canopy	16	16	5	37	113	24.7
Batch 3						
Normal	1	7	5	13	196	6.2
Okra	0	2	3	5	203	2.4
Super Okra	0	6	4	10	216	4.4
No Canopy	2	151	3	156	45	77.6
Batch 4						
Normal	1	6	11	18	177	9.2
Okra	0	3	4	7	191	3.5
Super Okra	0	4	1	5	217	2.3
No Canopy	38	30	3	71	64	52.6
Batch 5						
Normal	0	0	1	1	173	0.6
Okra	0	8	3	11	168	6.2
Super Okra	0	23	7	30	173	14.8
No Canopy	4	43	0	47	15	75.8
Batch 6						
Normal	0	0	1	1	160	0.6
Okra	0	2	3	5	132	3.7
Super Okra	0	15	3	18	121	13.0
No Canopy	1	25	2	28	11	71.8

Table 17. (Contd.)

Batch and Canopy	Observed Dead Weevils (no.) Larvae	Pupae	Adults	Total	Live Weevils (no.)	Percent* Dead Weevls
Batch 7						
Normal	0	1	8	9	193	4.5
Okra	0	0	6	6	166	3.5
Super Okra	0	9	9	18	110	14.1
No Canopy	0	0	0	0	0	-
Batch 8						
Normal	0	0	0	0	129	0.0
Okra	0	0	1	1	130	0.8
Super Okra	0	0	3	3	134	2.2
No Canopy	1	6	0	7	7	50.0
Batch 9						
Normal	0	15	0	15	170	8.1
Okra	0	46	2	48	122	28.2
Super Okra	0	103	0	103	54	65.6
No Canopy	0	42	0	42	8	84.0
Total of all Batches						
Normal	3	38	33	74	1578	4.5
Okra	3	68	24	95	1448	6.2
Super Okra	5	159	30	200	1326	13.1
No Canopy	63	315	13	390	267	59.4

* Percent Dead Weevils is calculated by the formula:

$$\frac{\text{Total Dead}}{\text{Total Dead} + \text{Total Live}} \times 100$$

Table 18. Mortality (identified) in immature boll weevil stages as affected by type of canopy at Baton Rouge, La., 1973.

Batch and Canopy	Observed Dead Weevils (no.)				Live Weevils (no.)	Percent* Dead Weevils
	Larvae	Pupae	Adults	Total		
Batch 1						
Normal	0	1	3	4	177	2.2
Okra	0	1	2	3	200	1.5
Super Okra	0	5	4	9	176	4.9
No Canopy	0	117	36	153	17	90.0
Batch 2						
Normal	0	3	2	5	213	2.3
Okra	0	1	1	2	209	1.0
Super Okra	1	2	0	3	232	1.3
No Canopy	1	88	2	91	8	91.9
Batch 3						
Normal	0	3	1	4	171	2.3
Okra	0	5	3	8	181	4.2
Super Okra	1	6	3	10	171	5.5
No Canopy	2	36	10	48	31	60.8
Batch 4						
Normal	0	0	0	0	185	0.0
Okra	0	2	0	2	176	1.1
Super Okra	0	2	0	2	167	1.1
No Canopy	1	146	0	147	5	96.7
Batch 5						
Normal	0	0	0	0	210	0.0
Okra	0	0	0	0	269	0.0
Super Okra	0	3	0	3	179	1.7
No Canopy	0	0	0	0	2	-
Batch 6						
Normal	0	1	0	1	158	0.6
Okra	0	0	0	0	158	0.0
Super Okra	0	0	0	0	157	0.0
No Canopy	0	1	0	1	132	1.5

Table 18. (Contd.)

Batch and Canopy	Observed Dead Weevils (no.) Larvae	Pupae	Adults	Total	Live Weevils (no.)	Percent* Dead Weevils
Total of all Batches						
Normal	0	8	6	14	1114	1.2
Okra	0	9	6	15	1193	1.2
Super Okra	2	18	7	27	1082	2.4
No Canopy	4	388	48	440	195	69.3

* Percent Dead Weevils is calculated by the formula:

$$\frac{\text{Total Dead}}{\text{Total Dead + Total Live}} \times 100$$

normal, okra, super okra and no canopy treatments, respectively (Table 17). As an average of six batches in 1973, the figures for the same were 1.2, 1.2, 2.4 and 69.3% in the same order (Table 18). These data indicate that there were more dead weevils (identified) under super okra and okra than under normal leaf canopy. Apparently, the reduction in weevil survival under okra, super okra and no canopy was due to higher soil surface temperatures under these canopies compared to normal leaf canopy.

Mortality (identified) in the pupal stage was observed to be the highest among the immature weevil stages. Out of a total of 759 dead forms in 1972 (inclusive of all four canopies), 580 were pupae, 74 were larvae and 100 were adults. In 1973, out of a total of 496 dead forms, 423 were pupae, 6 were larvae and 67 were adults. It was assumed that the portion that could not be accounted for as survival, was mortality. For example, if the total survival was 70%, the remaining (30%) was assumed as mortality. The observed (identified) mortality percentages for normal, okra, super okra and no canopy treatments in 1972 and 1973 when compared to the average percentage of weevil survival for those years (Tables 15, 16) show that the total mortality could have been much higher. The difference between the survival in laboratory at room temperature (reference sample) and that under each canopy was attributed to immature weevil mortality even though the actual dead forms were not identified. Most mortality occurs in the immature stages. Hinds (1907) observed that the greatest mortality occurred in the larval stage and the next highest was in the pupal stage. He reported that the ratio of mortality percentages in each weevil stage from heat was adult 1 : pupa 3 : larva 9. It may be mentioned that some mortality could have occurred at the egg stage. Either heat or tissue proliferation in the square could cause this mortality. Besides, the weevils might have died in early larval stage. Because of the very small size of dead larvae (also due to shrinkage) and/or due to the decomposition of those young dead larvae forms along with the floral tissue in the field, all the dead forms could not be identified. It may be reasonable to assume that if not all, at least most of the undetermined were dead forms.

Relationship Between Soil Surface Temperatures and Boll Weevil Survival

The correlation coefficient ('r') values for soil surface temperatures, the independent variable, and boll weevil survival, the dependent variable are presented in Table 19.

The data of 1972 only was used in the fitting of a regression equation for soil surface temperatures on boll weevil survival as there was little variation in the data on weevil survival under the three plant canopies in 1973. In all these studies, the data from no canopy treatment were deleted because of extreme values

Table 19. Correlations between percent boll weevil survival and the different expressions of soil surface temperatures at Baton Rouge, La., 1972 and 1973.

Year	r values											
Year	Avg. Daily Max. Temp.			Degree-hours above 85 F			Degree-hours above 90 F			Degree-hours above 90 F		
and	1st Wk.	2nd Wk.	Avg.	1st Wk.	2nd Wk.	Total	1st Wk.	2nd Wk.	Total	1st Wk.	2nd Wk.	Total
Batch	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
1972												
1	-0.86**	-0.78**	-0.87**	-0.84**	-0.40	-0.84**	-0.82**	0.00	-0.82**	-0.72**	0.00	-0.72**
2	-0.05	-0.01	-0.02	-0.18	-0.09	-0.04	0.00	0.00	0.00	0.00	0.00	0.00
3	0.40	0.36	0.41	0.01	0.39	0.37	0.00	0.43	0.43	0.00	0.00	0.00
4	0.03	0.61**	0.19	0.14	0.69**	0.35	0.07	0.38	0.13	0.00	0.00	0.00
5	-0.11	-0.09	-0.11	-0.04	-0.17	-0.16	-0.31	-0.23	-0.22	0.00	-0.33	-0.33
6	-0.47*	-0.54*	-0.52*	-0.35	-0.44	-0.42	-0.34	-0.41	-0.41	-0.29	-0.39	-0.38
7	-0.86**	-0.87**	-0.88**	-0.90**	-0.88**	-0.91**	-0.89**	-0.80**	-0.88**	-0.88**	-0.69**	-0.85**
8	0.09	0.21	0.16	0.05	0.09	0.08	-0.02	0.02	0.02	-0.07	-0.08	-0.08
9	-0.76**	-0.65**	-0.72**	-0.78**	-0.77**	-0.79**	-0.69**	-0.73**	-0.74**	-0.62**	-0.70**	-0.71**
All	-0.47**	-0.33**	-0.44**	-0.56**	-0.44**	-0.55**	-0.53**	-0.44**	-0.54**	-0.45**	-0.44**	-0.50**
All[illegible]	-0.60**	-0.42**	-0.56**	-0.67**	-0.52**	-0.67**	-0.63**	-0.51**	-0.64**	-0.54**	-0.48**	-0.58**
1973												
1	0.12	0.16	0.05	0.25	0.36	0.38	0.24	0.49*	0.39	0.00	0.00	0.00
2	0.36	0.45	0.44	0.10	0.25	0.19	0.07	0.08	0.04	0.00	0.00	0.00
3	0.23	-0.08	0.03	0.06	-0.07	-0.07	-0.13	-0.03	-0.03	0.00	-0.03	-0.03
4	-0.30	-0.17	-0.24	-0.27	-0.08	-0.19	-0.25	-0.05	-0.17	-0.18	-0.02	-0.12

Table 19. (contd.)

Year and Batch	Avg. Daily Max. Temp. 1st Wk. X1	Avg. Daily Max. Temp. 2nd Wk. X2	Avg. Daily Max. Temp. Avg. X3	Degree-hours above 85 F 1st Wk. X4	Degree-hours above 85 F 2nd Wk. X5	Degree-hours above 85 F Total X6	Degree-hours above 90 F 1st Wk X7	Degree-hours above 90 F 2nd Wk. X8	Degree-hours above 90 F Total X9	Degree-hours above 95 F 1st Wk. X10	Degree-hours above 95 F 2nd Wk. X11	Degree-hours above 95 F Total X12
	r values											
5	-0.70**	-0.67**	-0.70**	-0.79**	-0.62**	-0.75**	-0.79**	-0.55**	-0.72**	-0.79**	-0.57**	-0.73**
6	-0.60**	-0.50*	-0.57**	-0.53**	-0.44	-0.50*	-0.37	-0.44	-0.43	-0.41	-0.24	-0.40
All	-0.23*	-0.24*	-0.26**	-0.32**	-0.25**	-0.32**	-0.31**	-0.24*	-0.32**	-0.31	-0.22*	-0.31**

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

¶ All batches, except the 8th batch.

and little variation in weevil survival data. The effect of direct sun rays hitting the oviposited squares might itself be an important reason for weevil mortality (which was absent under plant canopies) besides the high soil surface temperatures. Therefore, to be able to predict the weevil survival under plant canopies, the regression equation was fitted using only the data of the three leaf type canopies. Also, the eighth batch of 1972 was avoided in the covariance studies because of defective data (extremely low actual weevil survival percentages in the laboratory or the reference sample and the absence of any effect of even high soil surface temperatures on weevil survival).

The covariance analysis indicated that the temperature during the first week were more important and also contributed more towards the immature weevil mortality than the temperatures during the second week of the 2-week exposure (developmental) period. It was also observed that (in simple correlation studies) in 1972, the degree-hours above 85 F during first week (X4) and total degree-hours above 85 F during the 2-week period (X6) were the most highly correlated temperature components ($r = -0.67$) with percent weevil survival (refer Fig. 2). The total degree-hours above 90 F during the 2-week period (X9) had an equally high correlation coefficient value ($r = -0.64$) with weevil survival. They accounted for about 45% variability in the percent weevil survival, when analyzed seperately. It may be particularly noted that the temperatures during first week alone were as important as those of the two weeks combined (comparing R square values).

The relationship between soil surface temperatures and boll weevil survival is illustrated in Fig. 2 for 1972. In the first batch of weevils studied in 1972, the weevil survival was substantially reduced under super okra leaf canopy as a result of high temperatures during the first week. Super okra accumulated a total of 311 degree-hours above 85 F, all in the first week while normal leaf had only 136.4 degree-hours above 85 F. The average maximum soil surface temperature under super okra canopy was 93.4 F in the first week while under normal leaf canopy it was only 88 F for the same period. There was no rain during the week preceding and the first week of exposure. All these factors together may have been responsible for the 60% reduction in weevil survival under super okra canopy over that of normal leaf.

In the sixth batch, only the average daily maximum soil surface temperatures were correlated with the weevil survival. This indicates that the average maximum soil surface temperatures may have been more important (in this period) in reducing the survival rate of boll weevils than the total degree-hours accumulated either in the first week or during both weeks. The temperatures during the first week were not very high and 1.67 inches of rainfall was received just three days prior to spreading the squares in the

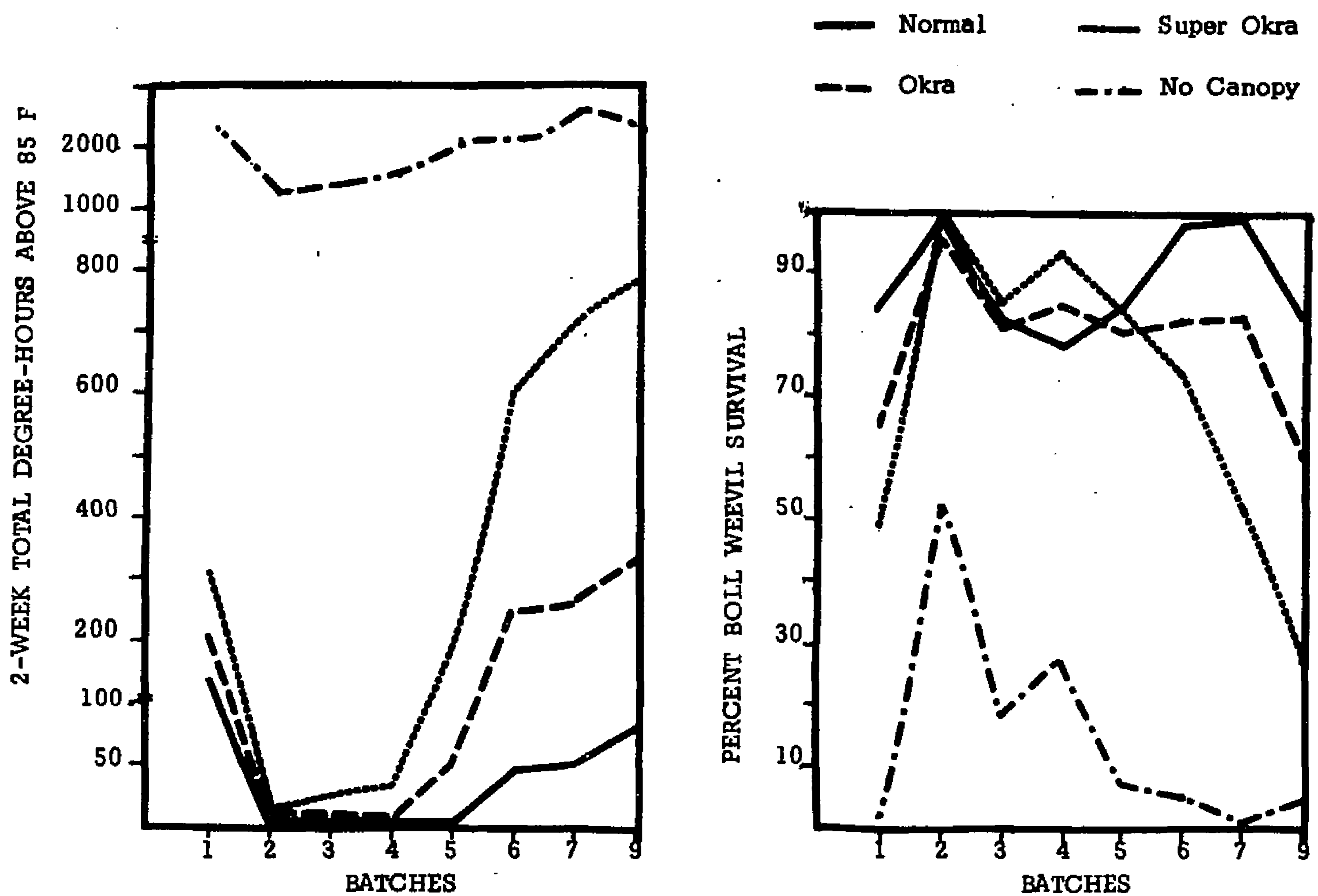

Fig. 2. Soil surface temperatures (left) and boll weevil survival as influenced by canopy type at Baton Rouge, La., 1972.

field. The temperatures were very high during the second week (average maximum temperature under super okra canopy was 102.7 F) but again there was rain during the last four days of the second week (2.09 inches). The percentage weevil survival under super okra was reduced by 23% (74% survival) compared to normal leaf canopy (96.7% survival). The weevil survival was not as low as would be expected of such high temperatures and that may have been due to the wet weather which is known to be favorable for the weevil development.

In the seventh batch, because of the high number of degree-hours (above 85 F) accumulated as well as the high average maximum soil surface temperatures under super okra (during both first and second weeks) the weevil survival was reduced (47% decrease over normal leaf). There were substantial number of degree-hours above 95 F under super okra.

In batch 9 a similar response was observed. The weevil survival was reduced by a phenominal 68% under super okra canopy over normal leaf canopy. The average maximum soil surface temperatures during the first and second weeks were 98.2 and 107.5 F, respectively, under super okra canopy. It is significant to note that there was no rainfall during the week preceding the actual exposure of squares and during the first week of exposure. There was a total rainfall of 0.76 inches for the whole 2-week period, received on one day during the second week (lowest for any batch). The dryness of the weather and the high soil surface temperatures must have been responsible for the drastic reduction in weevil survival.

In the other batches of 1972 (except the fourth batch) there were not any appreciable degree-hours to accumulate under any canopy, and consequently, no significant canopy effect on weevil survival. In the fourth batch also no appreciable number of degree-hours accumulated under any of the plant canopies, but the weevil survival under okra and super okra was significantly higher than under normal leaf canopy. The covariance analysis indicated that the percent survival and the (a) average daily maximum soil surface temperatures during the second week and (b) the degree-hours above 85 F during the second week were positively correlated, unlike in the other batches. The highest average maximum temperature was 86 F under super okra, in the second week. May be, the temperatures under normal leaf canopy were below optimum for weevil development while the temperatures under super okra and okra were nearer to the optimum. The period during this batch was also a wet one.

Under the no canopy treatment the weevil survival was very high (52.7%) in the second batch. The average maximum temperatures were quite high (about 110 F), but the whole 2-week period was very wet. Just a day prior to the spreading of squares there was a rainfall of 1.95 inches, and again during the second week 1.95 inches of rain was received. The second highest percentage weevil survival under no canopy was in the fourth batch (27.6%). The temperatures were as high as in the second batch, but again there was a continuous spell of rain (2.68 inches) during this period. In other batches of 1972, the temperatures in the no canopy treatment were very high and as a result, hardly few weevils survived.

The relationship between soil surface temperatures and boll weevil survival is illustrated in Fig. 3 for 1973. In 1973, only in batches 5 and 6 were there significant negative correlations between soil surface temperatures and weevil survival. Again, in the fifth batch, the weevil survival was more highly correlated with the soil surface temperatures of the first week than those of the second week. In the sixth batch, the weevil survival was quite high under all the plant canopies (ranging from 85.1 to 90.7%). The weevil survival under the no canopy treatment was also very high (61.4%), the highest for any batch. This may have been due to the excessively wet weather during this period. A total rainfall of 9.02 inches was received during this period, the highest for any batch in both years of study.

A regression equation was fitted to predict approximate percent weevil survival when data on temperature are available.

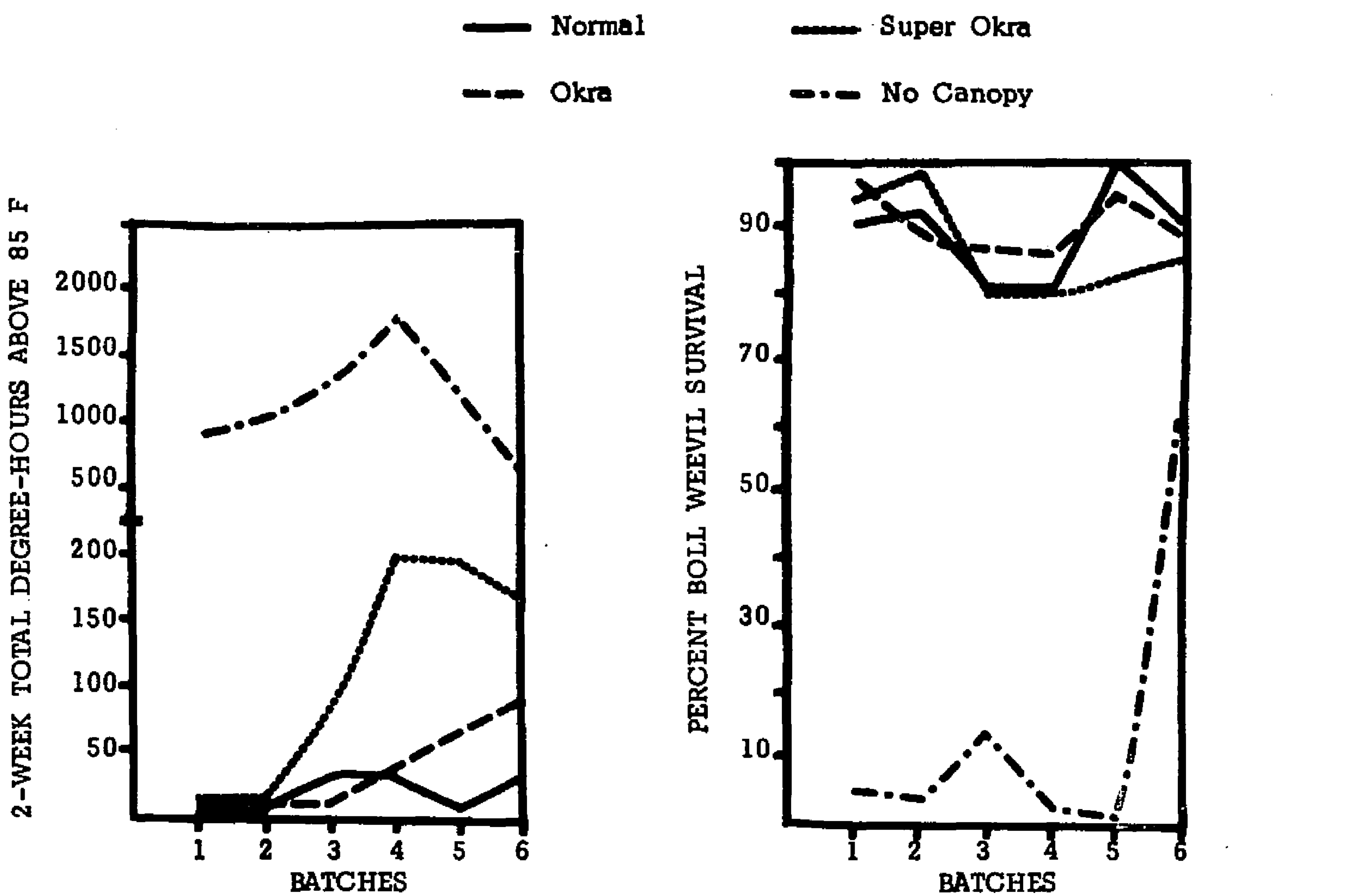

Fig. 3. Soil surface temperatures (left) and boll weevil survival (right) as influenced by canopy type at Baton Rouge, La., 1973.

A multiple linear regression study of the data was made. It was found that (1) the degree-hours above 85 F during the first week and the degree-hours above 85 F during the second week (X4 X5) together and (2) degree-hours above 85 F during the first week and degree-hours above 90 F during the second week (X4 X8) together, had the highest R square values (both, 0.49). The selection of the best regression equation was based on the (a) R square value (highest value), (b) sequential F test criterion and (c) sum of squares of deviations of actual weevil survival from the predicted weevil survival values $(Y - \hat{Y})$. For example, X4 X8 X10 (X10 = total degree-hours above 95 F during the first week) variables together had a slightly higher R square value than X4 X5 or X4 X8, but the sequential F test criterion showed that the additional contribution of X10 variable (given that the X4 and X8 variables were already in the equation) was not significant. So this model of three variables was rejected. Again, on the basis of the lowest sum of squares of deviations $(Y - \hat{Y})$ the regression equation with X4 X8 variables was selected. The regression equation involving X4 X5 variables may be as precise as the one involving X4 X8 variables in predicting weevil survival, for the difference in the sum of squares of deviations $(Y - \hat{Y})$ of the two equations was of relatively low magnitude. The two regression equations are presented :

(1) $\hat{Y} = 89.06 - 0.095(X4) - 0.052(X8)$

(2) $\hat{Y} = 89.55 - 0.094(X4) - 0.032(X5)$

where,

$\hat{Y}$ is the predicted percent weevil survival,

89.06 and 89.55 are the intercepts,

0.095, 0.052, 0.094 are the determined coefficients,

X4 = total degree-hours above 85 F for the first week,

X5 = total degree-hours above 85 F for the second week,

X8 = total degree-hours above 90 F for the second week.

The observed and predicted weevil survival values using the equation (1) are presented in Figure 4.

Several workers reported earlier on the effect of temperature on boll weevil survival in a similar tone. Hinds (1907) observed that heat was one of the two most important natural factors controlling boll weevil population, and that wider spacing (less shade on the ground) influences the effectiveness of heat on the insect. He noted that the proportion of clear to cloudy days and the relative rainfall influence, in considerable degree, the effectiveness of high temperatures. He further reported that nearly 70% of all mortality found from heat or drying occurred during the larval stage which is why probably, in this study, the temperatures during the first week of exposure were found to be more important than those of the second week in reducing the weevil survival. He noted that the mortality of boll weevil stages vary widely from

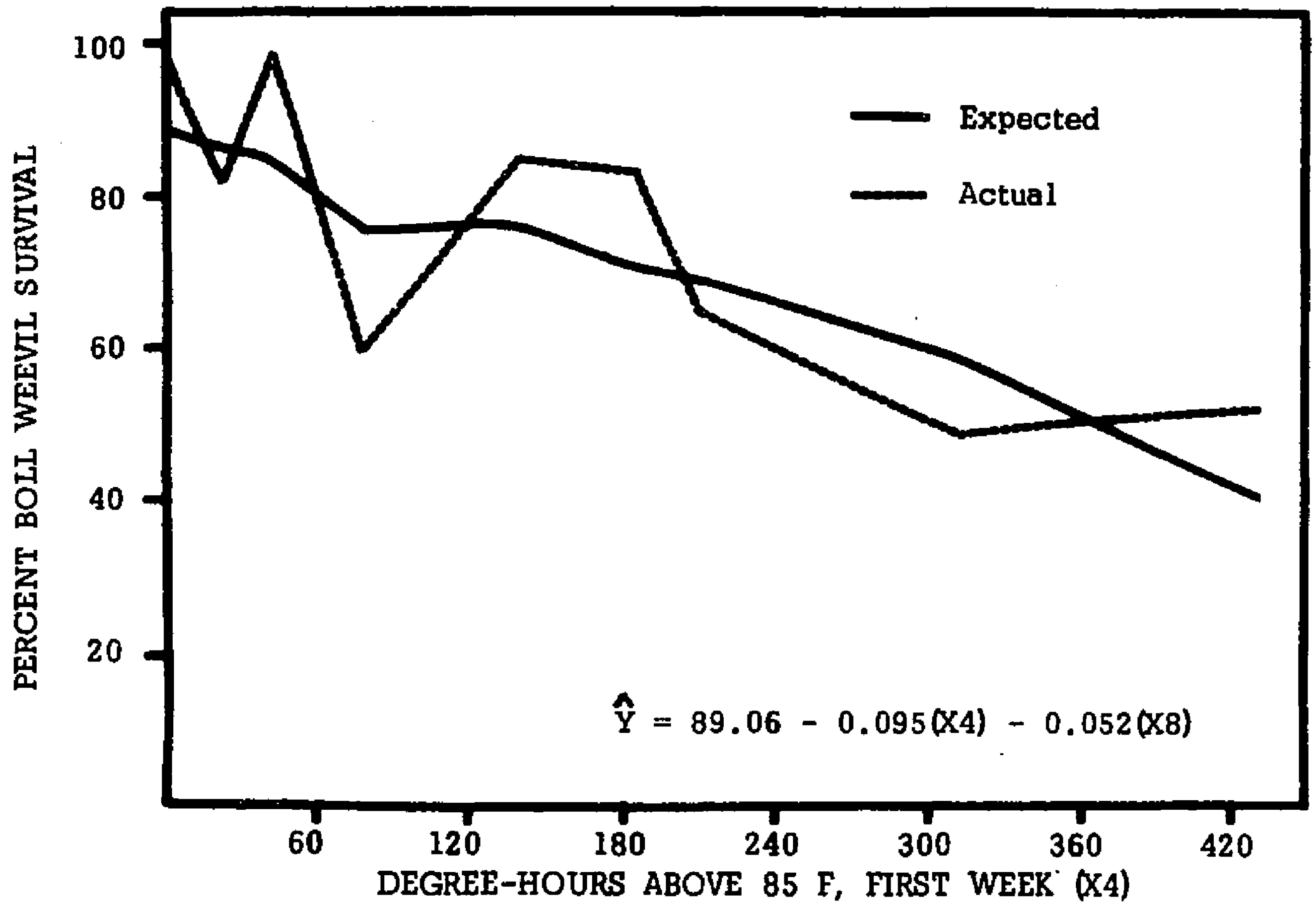

Fig. 4. Regression plotting showing the actual (Y) and expected ($\hat{Y}$) percentages of boll weevil survival.

locality to locality even if they have identical mean maximum temperatures. Pierce et al. (1912) reported that the maximum fatal temperature (to weevil) was 123 F. But in this study it was found that temperatures of lower magnitude than 123 F, if sustained long enough, were fatal to the boll weevil. Besides, the temperature fatal to the larval stage may be lower than that required for adult. Fenton and Dunnam (1929), Fenton and Hixon (1935) and Smith (1936) observed that high weevil mortality was coincident with periods of markedly deficient rainfall and high soil surface temperatures. Smith (1936) also noted that continued high (air) temperatures were not necessary to effect kill unless those temperatures were of low maxima that is, of the order of 90 to 94 F. He concluded that a single day of temperatures much above 95 F was sufficient to produce heavy mortality of the boll weevil in stages in contact with the earth and fairly exposed to the sun. The results obtained in this study are in general agreement with the above reports.

Fye and Bonham (1970) concluded that mortality in populations of immature boll weevils in fallen cotton squares on the soil surface, commenced when the summation of the index of time x temperature above 38 C (100.4 F) reached 60. They found that all the weevils died when the summation reached 550. But, this was based on laboratory data where the immature boll weevils were exposed to temperatures above 38 C for five hours per day and otherwise retained at 25 C (77 F) constant temperature until weevils emerged. They noted that the eggs and larvae used in the study were 4 to 11 days old when the exposures were started. They concluded that their tests included the youngest 75% of the immature weevils expected to fall with the punctured squares and that the mortality of immature weevils may have been slightly overestimated because the older larvae were not included in the test. In my own tests also the percent weevil survival may have been slightly underestimated because I had collected only freshly oviposited squares (unflared) and most of them may have been in egg stage. May be, that was why I found that even temperatures much below 38 C (100 F) were responsible for reducing boll weevil survival.

Boll Rot

The mean squares for boll rot and all other important agronomic characters are presented in Table 20. Estimated lint cotton lost due to boll rot (lb/acre) as affected by row type and leaf shape for three years at two locations is presented in Table 21.

As an average of years and treatments, estimated lint cotton losses per acre due to boll rot were 267 lb at Baton Rouge and 238 lb at St. Joseph. This represented a loss of 25.4 and 21.6% of the total lint yield at the two locations, respectively. There

Table 20. Mean squares for sources of variation of all characters statistically analyzed for three years at Baton Rouge and St. Joseph, and a combined analysis of years and locations.

Sources of variation	df	Mean Squares for Characters									
		Boll rot	Plant height	Lint yield	Earliness	Boll weight	Lint percentage	2.5% span length	Length uniformity	Fiber strength	Micronaire
Baton Rouge											
Years (Y)	2	379718**	0.797	2589157**	2067**	9.47**	0.33	0.0096**	38.77**	0.19	5.44**
Error (a)	15	17978	0.292	23857	173	0.16	0.82	0.0008	3.20	1.21	0.07
Row Type (R)	1	184512**	0.884**	1230507**	764*	1.84**	1.16	0.0011	0.48	0.47	0.42*
Y x R	2	52970*	0.199	52915**	163	0.11	1.64	0.0007	0.07	0.09	0.11
Error (b)	15	8963	0.066	4033	142	0.06	0.46	0.0005	1.23	0.57	0.05
Leaf Shape (Ls)	2	199141**	4.461**	26724*	12321**	1.82**	11.19**	0.0030**	20.52**	0.54	1.67**
Y x Ls	4	15903**	0.025	19670*	348**	0.13	1.52	0.0004	2.32	0.13	0.36**
R x Ls	2	505	0.024	30111*	236	0.06	2.26	0.0001	0.21	0.30	0.06
Y x R x Ls	4	7665	0.049	7406	109	0.04	0.35	0.0003	2.83	0.43	0.05
Error (c)	60	3995	0.042	5617	83	0.06	0.83	0.0003	1.48	0.29	0.03
St. Joseph											
Years (Y)	2	736767**		381327**	7872**	9.87**	72.72**	0.0509**	11.75**	11.89**	0.23
Error (a)	14	26939		14268	371	0.11	2.09	0.0009	1.25	1.47	0.07
Row Type (R)	1	40004		710669**	228	0.67**	6.23	0.0006	1.45	0.45	0.01
Y x R	2	39032		12232	182	0.20*	0.50	0.0002	13.69**	0.50	0.32*
Error (b)	14	25228		17105	316	0.05	1.38	0.0003	1.53	0.90	0.05
Leaf Shape (Ls)	2	66772**		40931**	2305*	0.43**	12.55**	0.0038**	2.72	7.84**	0.05
Y x Ls	4	24142**		20376**	131	0.20**	1.01	0.0005	0.61	2.22**	0.12*
R x Ls	2	8426		1544	30	0.03	0.11	0.0001	0.03	0.95	0.02
Y x R x Ls	4	6664		11471*	24	0.04	0.66	0.0002	0.14	0.27	0.04
Error (c)	56	2892		4195	88	0.05	0.52	0.0002	1.16	0.46	0.04

Table 20. (contd.)

Sources of variation	df	Boll rot	Plant height	Lint yield	Earliness	Boll weight	Lint percentage	2.5% span length	Length uniformity	Fiber strength	Micronaire
		Mean Squares for Characters									
Combined Analysis											
Locations (L)	1	43519		161530*	37369**	0.54	209.51**	0.0253**	79.20**	64.62**	0.03
Years (Y)	2	91603*		682381**	2628**	5.20**	41.44**	0.0504**	20.31**	4.68*	4.08**
L x Y	2	1024883**		2288104**	7312**	14.14**	31.61**	0.0102**	30.21**	7.40**	1.59**
Error (a)	29	22304		19233	269	0.14	1.43	0.0008	2.26	1.34	0.07
Row Type (R)	1	200201**		1912770**	921	2.38**	0.93	0.0016	0.12	0.92	0.28*
L x R	1	24315		28406	71	0.13	6.45*	0.0000	1.81	0.00	0.15
Y x R	2	53249		23155	16	0.18	1.85	0.0004	6.88*	0.07	0.03
L x Y x R	2	38752		41991*	328	0.13	0.29	0.0005	6.88*	0.51	0.40
Error (b)	29	16815		10344	226	0.05	0.91	0.0004	1.38	0.73	0.05
Leaf Shape (Ls)	2	246028**		62253**	12778**	1.89**	20.84**	0.0066**	17.47**	6.04**	0.81**
L x Ls	2	19885**		4862	1848**	0.36**	2.81*	0.0002	5.77*	2.34**	0.93**
Y x Ls	4	17308**		17643**	347*	0.04	2.02*	0.0006*	1.12	1.46**	0.11*
L x Y x Ls	4	22743**		22403**	132	0.29**	0.52	0.0002	1.81	0.89	0.38**
R x Ls	2	2516		22720*	59	0.02	1.51	0.0000	0.06	0.09	0.07
L x R x Ls	2	6415		8935	207	0.07	0.86	0.0001	0.19	1.16*	0.01
Y x R x Ls	4	8844		16952*	82	0.03	0.37	0.0002	1.58	0.49	0.06
L x Y x R x Ls	4	5485		1925	51	0.06	0.64	0.0003	1.39	0.21	0.03
Error (c)	116	3462		4930	86	0.05	0.68	0.0002	1.32	0.37	0.03

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

Table 21. Mean boll rot (lint loss, lb/acre) as affected by row type and leaf shape of upland cotton.

Locations and Leaf Shape Genotypes	1971 Solid	1971 Skip	1971 Avg.	1972 Solid	1972 Skip	1972 Avg.	1973 Solid	1973 Skip	1973 Avg.	Average Solid	Average Skip	Average Avg.
Baton Rouge												
Normal	273	253	263a*	369	533	451a	246	374	310a	296	387	341a
Okra	201	243	222a	310	427	368b	169	254	212b	227	308	267b
Super Okra	158	157	158b	237	437	337b	69	97	83c	154	230	193c
Average	211x	218x	214	305y	466x	385	161y	242x	202	226y	308x	267
St. Joseph												
Normal	533	432	483a	81	103	92a	247	319	283a	272	276	274a
Okra	410	407	409b	100	111	105a	184	352	268a	221	283	252a
Super Okra	267	315	291c	81	95	88a	156	253	205b	162	215	189b
Average	403x	385x	394	87x	103x	95	196x	308x	252	218x	258x	238
Average of Locations												
Normal	391	334	363	225	318	271	246	346	296	284	333	309a
Okra	296	317	307	205	269	237	177	303	240	224	296	260b
Super Okra	207	229	218	159	266	212	113	175	144	158	223	191c
Average	298	294	296	196	284	240	178	274	227	222y	284x	253

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y, are used in rows.

were significant differences among years in pounds of lint cotton lost per acre, at each location. The boll rot losses ranged from 202 (1973) to 385 lb/acre (1972) at Baton Rouge, and from 95 (1972) to 394 lb/acre (1971) at St. Joseph.

Row type had significant effect on boll rot losses. As an average of years and locations, skip-row planting resulted in higher boll rot losses (284 lb/acre) than solid planting (222 lb/acre). But, skip-row planting also resulted in substantial increases in yield. So, when boll rot was expressed as a percentage of total crop, this represented an yield loss of 22.8% for skip-row compared to 24.5% for solid-row. Higher boll rot under skip-row (lb/acre) may have been partly due to the fact that more bolls were available for boll rot attack. But, based on yield potential, it indicates that skip-row planting has slightly reduced boll rot losses over solid planting. Though the location x row type interaction was not significant in the combined analysis, individual analysis for each location had shown that differences between row types were significant at Baton Rouge but not at St. Joseph.

There were highly significant differences among leaf shapes. Normal leaf lost the greatest amount of lint due to boll rot (309 lb/acre) followed by okra (260 lb/acre) and super okra being the lowest (191 lb/acre), as an average of years and locations. All three leaf shapes were significantly different from each other. These losses represented 26.1, 24.5 and 19.3% of the total crop for normal, okra and super okra, respectively. Comparing the pounds of lint cotton lost from boll rot, super okra caused a reduction of 38.2% and okra caused a reduction of 15.9% in boll rot losses over normal leaf. But, when boll rot losses were expressed as a percentage of total crop, super okra and okra, respectively, caused a reduction of 26.1 and 6.1% in boll rot losses over normal leaf.

The leaf shapes x locations, leaf shapes x years and leaf shapes x locations x years interactions were found to be highly significant, indicating that leaf shapes were influenced differently by years and locations. These significant interactions were due to the fact that the differences between leaf shapes were not consistent though the general trend of leaf shapes remained the same as reported earlier.

The interaction between row types x leaf shapes was not significant at either location or in the combined analysis. But, the years x row types x leaf shapes interaction was significant, indicating that the row type x leaf shape interaction varied in each year.

Jones and Andries (1967), in their evaluation of near isogenic populations of okra and normal leaf cottons at two locations in Louisiana, reported that the okra leaf was associated with a 50%

reduction in the incidence of boll rot. Andries et al. (1969), studying normal, okra and mixed leaf treatments at three locations in Louisiana, reported that normal leaf and okra leaf treatments lost 18.3 and 10.3% of their total crops from boll rot, respectively. Okra leaf caused approximately 45% reduction in the incidence of boll rot over normal leaf. In another study, the same authors (1970) reported that, as an average of three locations in Louisiana, super okra caused approximately 55% reduction in the incidence of boll rot over normal leaf. Major (1971) reported no differences between normal leaf and okra leaf as far as boll rot was concerned. Bird (1973) reported that okra leaf shape gave a 13% gain in healthy bolls over normal which was associated with a 9% gain in yield. Much earlier, Brown and Cotton (1937), after testing an okra leaf strain of Delfos cotton for several years during the 1930's in Louisiana, reported that the okra leaf strain had fewer rotten bolls than the broad leafed varieties. Though the magnitude of differences between the leaf shapes as reported by Jones et al. (1967) and Andries et al. (1969, 1970) were not observed in this study, the general trend of the leaf shapes conforms to their findings. The reduction in the incidence of boll rot by okra and super okra leaf shapes may be attributed mostly to their more open canopies resulting in increased light penetration and lower humidity within the canopy (reported earlier elsewhere in this study) and to shorter periods of boll opening. The weather conditions during boll opening are very important.

Important Agronomic Characters

Plant Height

Mean plant height (final) as affected by row type and leaf shape for three years at Baton Rouge is given in Table 22.

The plant height did not vary significantly due to years, but was significantly affected by row types, as an average of years. Skip-row planting resulted in taller plants (3.89 feet) compared to solid planting (3.71 feet).

Leaf shape also significantly affected the plant height. Okra leaf was the tallest (4.06 feet) followed by normal (3.94 feet) and super okra leaf (3.40 feet), each year. The three leaf shapes were significantly different from each other.

There was no significant row type x leaf shape interaction, indicating that the row types did not affect the behaviour of leaf shapes.

Major (1971) reported no difference in plant height between near isogenic strains of normal and okra. Andries (1972) reported that okra (La. Okra-2) was slightly taller than normal (Stoneville 7A) which again was significantly taller than super okra (La. Super Okra-2). The results of this study are in complete agreement with

Table 22. Mean plant height (feet) as affected by row type and leaf shape of upland cotton at Baton Rouge, La.

Leaf Shape Genotypes	Years: 1971 Solid	Skip	Avg.	1972 Solid	Skip	Avg.	1973 Solid	Skip	Avg.	Average Solid	Skip	Avg.
Normal	3.98	4.00	3.99	3.91	4.21	4.06	3.58	3.97	3.78	3.82	4.06	3.94b*
Okra	4.23	4.17	4.20	3.94	4.30	4.12	3.80	3.94	3.87	3.99	4.14	4.06a
Super Okra	3.46	3.57	3.51	3.30	3.59	3.44	3.22	3.27	3.25	3.32	3.48	3.40c
Average	3.89	3.91	3.90	3.71	4.03	3.87	3.53	3.73	3.63	3.71y	3.89x	3.80

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y are used in rows.

the findings of Andries (1972).

Lint Yield

The lint cotton yield as affected by row type and leaf shape for three years at two locations is presented in Table 23.

There were differences in yield of lint due to years and locations. At Baton Rouge the highest yield (1193 lb/acre) was obtained in 1972 and the lowest (424 lb/acre) in 1973, while at St. Joseph the highest yield (1035 lb/acre) was obtained in 1973 and the lowest (770 lb/acre) in 1971.

Skip-row plantings gave significantly higher yields than solid planting at each location and in each year. As an average of years and locations, skip-row planting yielded 40% higher than solid planting. Greatest average increase in yield due to skip-row (48.5%) occurred at Baton Rouge while St. Joseph registered a 32.2% average increase. The years x row type interaction was significant at Baton Rouge but not at St. Joseph. The significant interaction of years x row type at Baton Rouge was due to variation in the magnitude of differences between row types each year. Skip-row planting at Baton Rouge resulted in 55.6, 41.4 and 57.8% higher yields than solid planting in 1971, 1972 and 1973, respectively. The figures for the same at St. Joseph were 25.3, 39.6 and 31.3%. The location x row type interaction was not significant, indicating that the effects of row types remained the same at both locations.

Table 23. Mean lint yield (lb/acre) as affected by row type and leaf shape of upland cotton.

Locations and Leaf Shape Genotypes	Years											
	1971			1972			1973			Average		
	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.
Baton Rouge												
Normal	571	1013	792a*	1086	1502	1294a	322	483	402a	660a	999a	829a
Okra	539	891	715a	929	1432	1180b	307	561	434a	592a	961a	776b
Super Okra	632	806	719a	948	1259	1104b	359	513	436a	646a	859b	753b
Average	581	904	742	988	1397	1193	329	519	424	633y	940x	786
St. Joseph												
Normal	732a	976a	854a	715a	941a	828a	947a	1201a	1074a	802	1043	922a
Okra	696a	888a	792a	538b	887a	712b	862a	1089b	975b	699	958	829b
Super Okra	622a	706b	664b	695a	891a	793a	875a	1234a	1055a	737	958	847b
Average	684	857	770	649	906	778	895	1175	1035	746y	986x	866
Average of Locations												
Normal	644	996	820	901	1221	1061	634	842	738	729a	1021a	875a
Okra	610	889	750	734	1159	946	584	825	705	644b	960b	802b
Super Okra	628	761	694	822	1075	948	617	874	745	690ab	907c	799b
Average	627	882	755	819	1152	985	612	847	729	688y	963x	825

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y are used in rows.

Bruce (1965) reported an increase of 27 to 34% in yield due to 2 x 1 skip-row planting over solid planting. He attributed this increase in yield partly to the additional soil water available to the plants from the skip-rows. Melville and Oakes (1966) reported an increase of 41 to 62% in yield due to 2 x 1 skip-row planting over solid planting. Similar increases in yield due to skip-row planting were reported by Bridge et al. (1967) and Hawkins and Peacock (1968). The increase in yield due to skip-row planting may have been due to the additional moisture, light and nutrients made available to plants from skip-rows and due to lesser competetion among plants for these factors. Results obtained in this study are in agreement with those of earlier workers.

At each location and as an average of locations, normal leaf yielded significantly higher lint yield per acre than okra and super okra as an average of three years. But, the differences between okra and super okra were not statistically significant. The years x leaf shape interaction was significant at both locations, indicating differential leaf shape responses due to changes in environment. In 2 out of 3 years (1971 and 1973) at Baton Rouge, the three leaf shapes did not differ in yield from each other, but, in 1972, normal yielded significantly higher than okra and super okra. At St. Joseph, the three leaf shapes behaved differently each year. In 1971, normal and okra did not differ from each other, but both yielded significantly higher than super okra. In 1972 and 1973, normal and super okra did not differ from each other, but both were significantly higher than okra in yield.

At Baton Rouge and as an average of locations, there was a significant interaction between row types and leaf shapes, indicating that the three leaf shapes behaved differently under each row type. As an average of locations, under solid planting, normal yielded significantly higher than okra and super okra, while okra did not differ from super okra. But, under skip-row planting normal yielded significantly more than okra which again yielded significantly more than super okra. At Baton Rouge, the three leaf shapes did not differ from each other under solid planting. But, under skip-row planting, though normal and okra did not differ from each other, both yielded significantly more than super okra. These results indicate that super okra could not compensate for wide spacing or low plant population (skip-row) as well as normal or okra leaf shapes. This may be because of its sparser foliage and smaller plant size compared to normal and okra leaf shapes (Andries et al., 1969 and 1970).

That the normal leaf shape yielded higher than okra leaf shape as has been found in this study is supported by similar findings of Brown and Cotton (1937), and Kohel et al. (1965). However, Cook and Doyle (1927), Caine (1948), Jones and

Andries (1967), Major (1971) and Andries (1972) reported that there was no significant difference between normal and okra leaf shapes in yield. But, Andries et al. (1969) reported that okra yielded significantly more than normal. Andries et al. (1970) and Andries (1972) reported that normal leaf yielded significantly more than super okra. Andries (1972) also reported that okra yielded significantly more than super okra. The results obtained in this study are in partial agreement with these reports.

Earliness

Mean earliness, expressed as percent of total yield harvested at first picking, as affected by row type and leaf shape for three years at two locations is presented in Table 24.

The duration (number of days) between the planting date and the first picking varied from year to year and location to location. Therefore, the actual percentages of total crop harvested at first picking might mislead us. The differences in actual values between years and locations may have been due partly to different dates of pickings (different durations of planting to first picking). However, the interactions of treatments x years and treatments x locations can be studied by looking at the relative significance ratings of the treatments for that year or location. For this reason, the discussion of effects of years, locations and years x locations has been avoided.

Table 24. Earliness expressed as mean percentage of total crop harvested at first picking as affected by row type and leaf shape of upland cotton.

Locations and Leaf Shape Genotypes	Years											
	1971			1972			1973			Average		
	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.
Baton Rouge												
Normal	24.9	21.0	23.0c*	23.2	24.4	23.8c	19.2	16.5	17.8c	22.4	20.6	21.5c
Okra	49.0	44.1	46.5b	39.0	30.9	34.9b	23.9	28.1	26.0b	37.3	34.3	35.8b
Super Okra	74.7	66.3	70.5a	63.6	42.4	53.0a	53.2	49.1	51.2a	63.8	52.6	58.2a
Average	49.5	43.8	46.7	41.9	32.5	37.2	32.1	31.2	31.7	41.2x	35.9y	38.5
St. Joseph												
Normal	45.7	35.0	40.3	74.9	77.6	76.2	58.0	50.5	54.2	60.3	55.5	57.9c
Okra	49.3	46.1	47.7	77.0	77.0	77.0	66.5	60.5	63.5	65.1	62.1	63.6b
Super Okra	58.1	57.3	57.7	83.9	87.3	85.6	79.3	73.4	76.4	74.7	73.6	74.1a
Average	51.0	46.1	48.6	78.6	80.6	79.6	67.9	61.5	64.7	66.7x	63.7x	65.2
Average of Locations												
Normal	34.3	27.4	30.9	49.0	51.0	50.0	38.6	33.5	36.0	40.8	37.5	39.2c
Okra	49.1	45.0	47.1	58.0	53.9	55.9	45.2	44.3	44.8	50.8	47.8	49.3b
Super Okra	67.1	62.2	64.7	73.7	64.9	69.3	66.3	61.3	63.8	69.1	62.8	65.3a
Average	50.2	44.9	47.5	60.2	56.6	58.4	50.0	46.4	48.2	53.6x	49.4x	51.5

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y are used in rows.

As an average of years and locations, the percentage of total crop harvested at first picking was 53.6 in solid-row and 49.4 in skip-row. The calculated F value (4.08) very closely approached the required F value (4.11) for significance at the 5% level of probability but did not quite equal it. Therefore, the differences may have been real in spite of the apparently nonsignificant F value. There was no significant interaction between row types and locations in the combined analysis. Though there were some exceptions, the data generally showed that the solid-row was relatively earlier than skip-row, especially at Baton Rouge. Hawkins and Peacock (1964) also reported a greater percentage of the crop harvested at first picking from solid-row (62%) than from skip-row (55.5%).

Leaf shapes had a highly significant effect on earliness at each location and in the combined analysis. At both locations and as an average of locations, super okra had the highest percentage of crop harvested at first picking (65.9) followed by okra (49.3) and normal (39.2). The year x leaf shape and location x leaf shape interactions were significant in the combined analysis. This may have been due partly to differences in the durations from planting to first picking, and partly to the variations in the magnitude of differences between leaf shapes. However, in all the three years and at each location, super okra had the highest percentage of total yield harvested at first picking followed by okra and normal.

There was no significant row type x leaf shape interaction, indicating that the leaf shapes were not influenced by row types.

The above results are supported by similar findings reported by earlier workers. Cook and Doyle (1927) observed that the okra leaf type was earlier than the normal leaf type of Acala in their studies in California. Andries et al. (1969) reported that the okra leaf type was significantly earlier than its near isogenic normal leaf type in Louisiana. Andries et al. (1970) found that the super okra leaf shape had a much higher percentage of the total yield harvested at first picking than its normal leaf isoline. Similar results were obtained by Major (1971). Andries (1972) reported that normal leaf and okra leaf did not differ from each other, but the super okra leaf shape had a significantly higher percentage of crop harvested at first picking than normal and okra leaf shapes.

Results from a more detailed study of earliness conducted at Baton Rouge are summarized in Figs. 5, 6 and 7 for 1971, 1972 and 1973 years, respectively.

While there was no difference between solid and skip-row plantings in 1971 and 1973, solid-row plots had 70% of the crop open 2.5 days earlier than skip-row plots in 1972 as an average

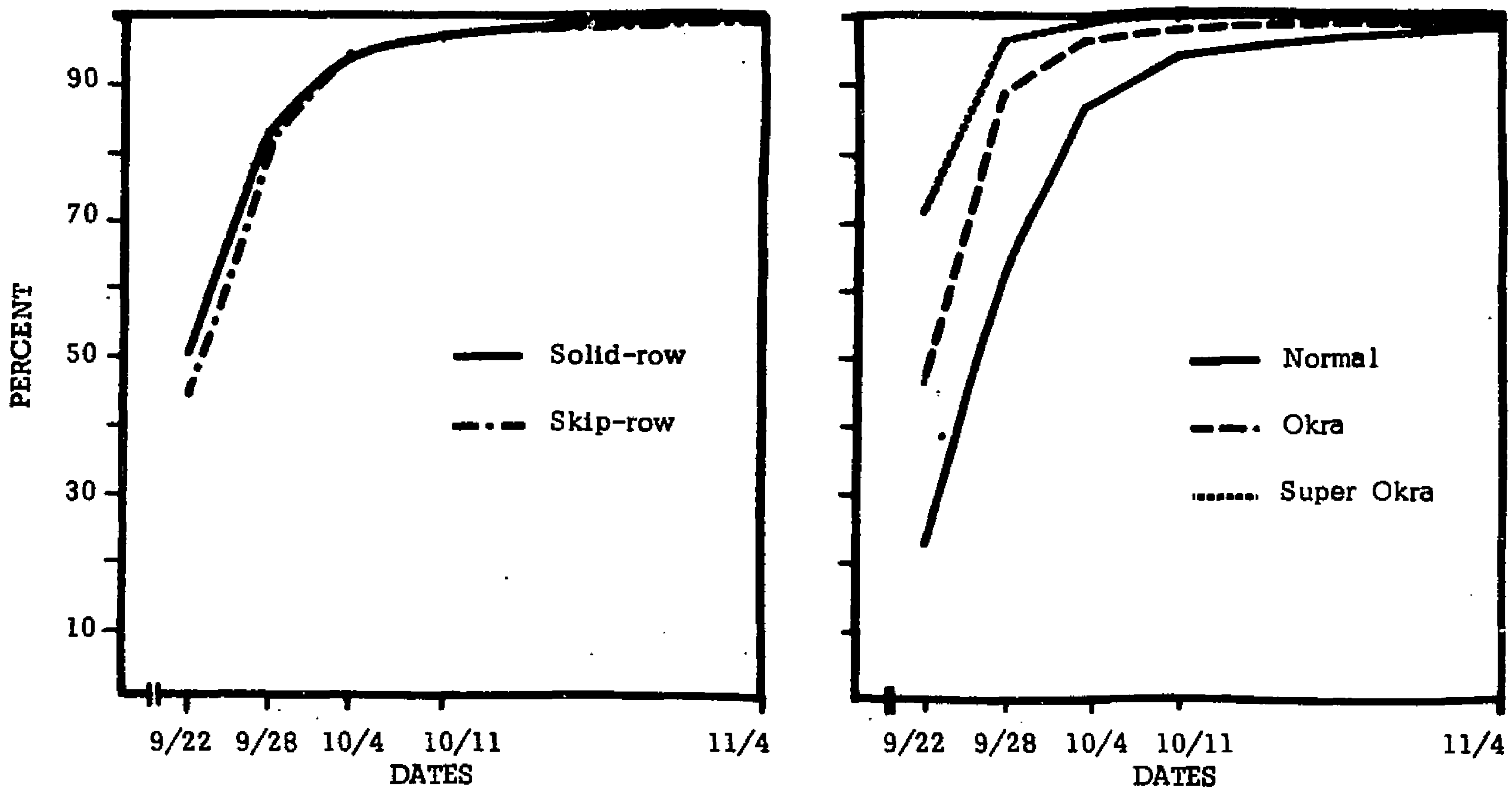

Fig. 5. Effect of row type and leaf shape on percentage of total crop harvested, by dates, at Baton Rouge, La., 1971.

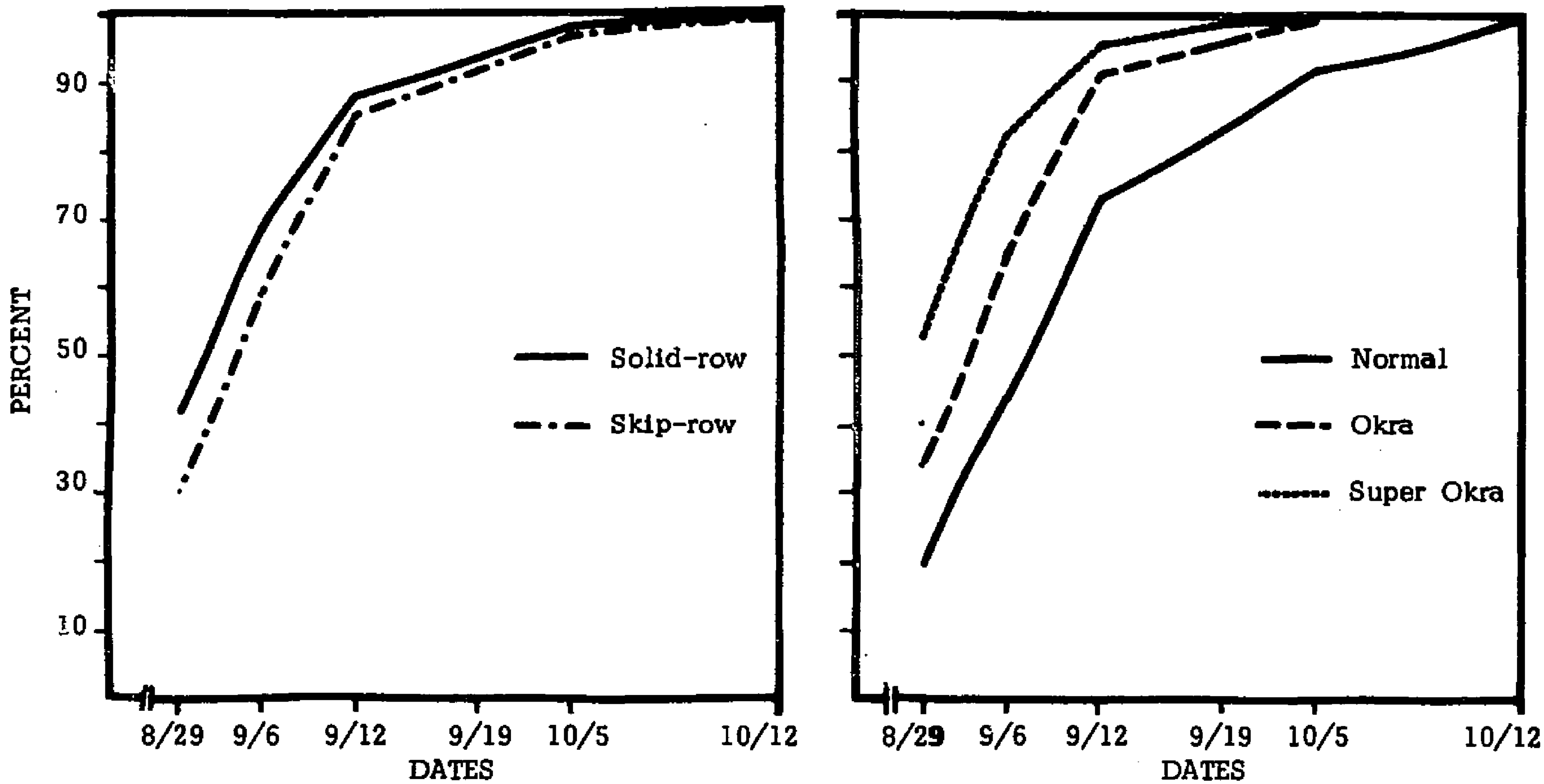

Fig. 6. Effects of row types and leaf shapes on percentage of total crop harvested, by dates, at Baton Rouge, La., 1972.

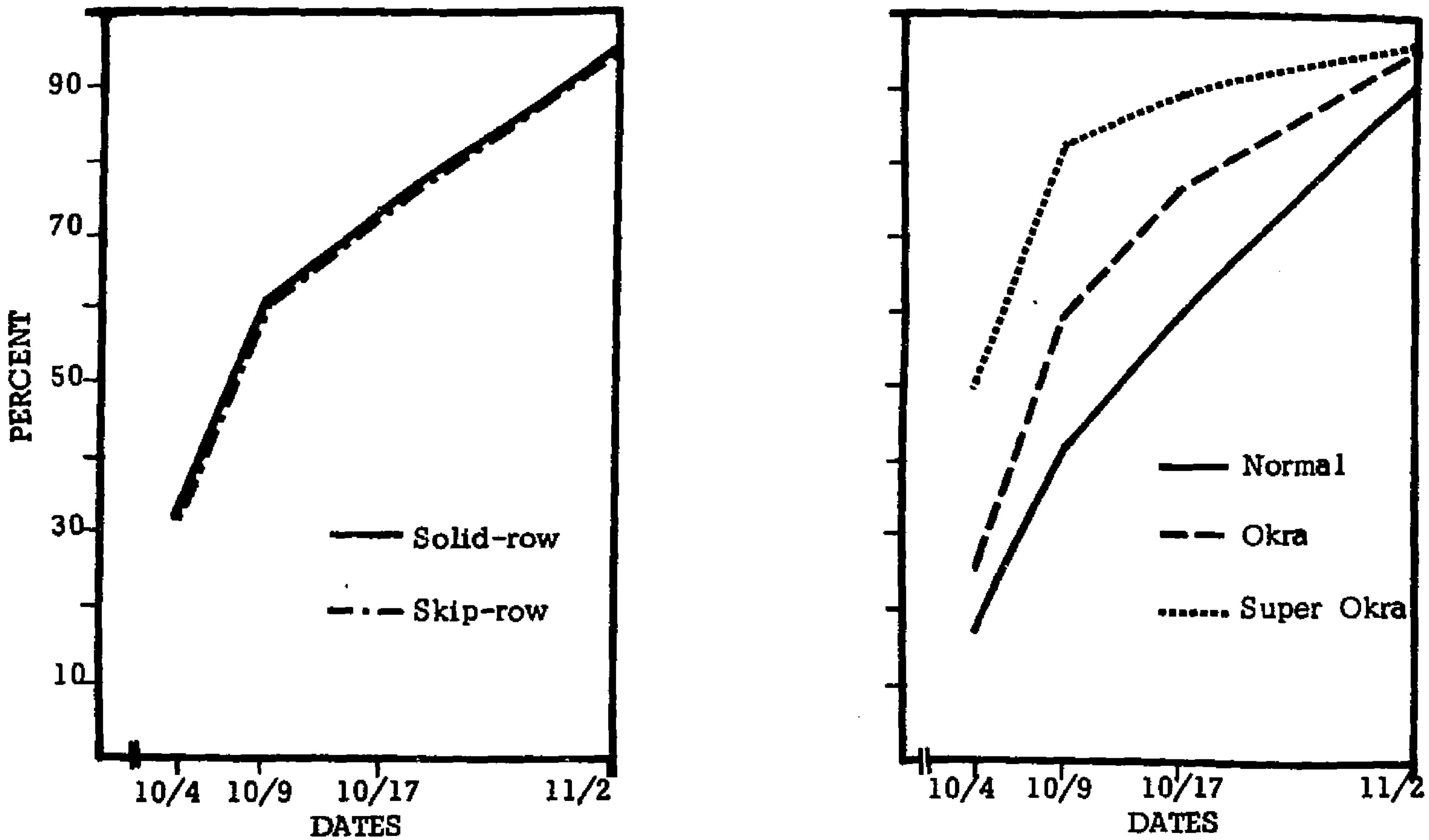

Fig. 7. Effects of row types and leaf shapes on percentage of total crop harvested, by dates, at Baton Rouge, La., 1973.

of leaf shapes.

The data show that if first harvest was delayed until approximately 70% of the crop is open, as is generally recommended, super okra leaf plots could have been harvested an average of 5.3 and 11 days earlier than the okra and normal leaf plots, respectively. The okra leaf plots had 70% of its crop open six days earlier than normal leaf plots.

These results (on leaf shapes) are substantiated by earlier reports of Jones and Andries (1967) and Andries et al. (1969, 1970) who had found that okra leaf shape was 5 to 6 days earlier and super okra was 12 days earlier than normal leaf shape, if harvested when 70% of the crop is open.

Boll Weight

Mean boll weight, as influenced by row types and leaf shapes for three years at two locations is presented in Table 25.

Mean boll weight was not affected by locations or years, nor was the years x locations interaction significant.

Skip-row planting resulted in a significantly higher mean boll weight than solid planting at each location and as an average of locations. The years x row type interaction was not significant either at Baton Rouge or in the combined analysis, but was significant at St. Joseph. This interaction was considered relatively

Table 25. Mean boll weight (grams) as affected by row type and leaf shape of upland cotton.

Locations and Leaf Shape Genotypes	Years											
	1971			1972			1973			Average		
	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.
Baton Rouge												
Normal	5.72	6.04	5.88	5.35	5.81	5.58	4.68	4.84	4.76	5.25	5.57	5.41a*
Okra	5.44	5.88	5.51	5.20	5.63	5.41	4.48	4.82	4.66	5.04	5.34	5.19b
Super Okra	5.21	5.22	5.21	5.17	5.40	5.29	4.25	4.50	4.38	4.87	5.04	4.96c
Average	5.46	5.61	5.53	5.24	5.61	5.43	4.47	4.72	4.60	5.06y	5.32x	5.19
St. Joseph												
Normal	5.52	5.46	5.49a	4.65	4.88	4.77a	5.63	5.97	5.80a	5.25	5.44	5.34a
Okra	5.67	5.69	5.68a	4.80	4.72	4.76a	5.53	5.85	5.69a	5.32	5.41	5.36a
Super Okra	5.57	5.67	5.62a	4.44	4.65	4.55a	5.23	5.53	5.38b	5.05	5.26	5.16b
Average	5.59x	5.61x	5.60	4.63x	4.75x	4.69	5.46y	5.79x	5.62	5.21y	5.37x	5.29
Average of Locations												
Normal	5.63	5.78	5.70	5.00	5.35	5.17	5.15	5.41	5.28	5.25	5.50	5.38a
Okra	5.55	5.63	5.59	5.00	5.17	5.09	5.00	5.34	5.17	5.17	5.37	5.27b
Super Okra	5.37	5.42	5.40	4.81	5.03	4.92	4.74	5.02	4.88	4.96	5.15	5.05c
Average	5.51	5.61	5.56	4.94	5.18	5.06	4.97	5.25	5.11	5.13y	5.34x	5.23

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y are used in rows.

unimportant since it was due to minor variation in the magnitude of differences between row types; the trend remained essentially the same in all three years.

Leaf shape had highly significant effect on average boll weight. As an average of locations and years, normal leaf had the highest average boll weight followed by okra and super okra in that order. The differences were statistically significant. Similar results were obtained at Baton Rouge. But, at St. Joseph, normal and okra leaf shapes had almost the same average boll weights, and both were significantly higher than super okra. The location x leaf shape interaction was, therefore, significant. Andries et al. (1969, 1970), based on two seperate tests and as an average of three locations in Louisiana, reported that normal leaf did not differ from okra and super okra leaf shapes in average boll weight. Andries (1972) reported that there were no significant differences in average boll weights of normal, okra and super okra leaf shapes. The results obtained in this study are in conflict with the above reports.

The row type x leaf shape interaction was not significant, indicating that the effects of row types on boll size were similar for the three leaf shapes.

Lint Percentage

Lint percentage as affected by row types and leaf shapes for three years at two locations is presented in Table 26.

Lint percentage was significantly affected by locations and years. There was a highly significant locations x years interaction. Higher average lint percentage was recorded at Baton Rouge (38.7) than at St. Joseph (36.7). While the lint percentage remained practically the same every year at Baton Rouge, it varied each year at St. Joseph.

Row type did not affect the lint percentage significantly at either location or in the combined analysis. However, the row type x location interaction was found to be significant because of variation in the magnitude of difference between row types at the two locations. Hawkins and Peacock (1968) also reported that lint percentage was not affected by row type.

Leaf shape significantly affected the lint percentage at each location and in the combined analysis. As an average of locations, normal leaf had significantly higher lint percentage than super okra which again had higher lint percentage than okra leaf. There was a location x leaf shape interaction. At Baton Rouge, normal leaf was significantly different from okra leaf but not from super okra. At St. Joseph, normal leaf had significantly higher lint percentage than okra and super okra while the latter two did

Table 26. Mean lint percentage (%) as affected by row type and leaf shape of upland cotton.

Location and Leaf Shape Genotypes	Years 1971 Solid	1971 Skip	1971 Avg.	1972 Solid	1972 Skip	1972 Avg.	1973 Solid	1973 Skip	1973 Avg.	Average Solid	Average Skip	Average Avg.
Baton Rouge												
Normal	39.1	40.0	39.6	38.1	39.6	38.8	39.7	39.6	39.6	38.9	39.7	39.3a*
Okra	38.1	38.2	38.2	38.3	38.5	38.4	38.2	38.1	38.1	38.2	38.2	38.2b
Super Okra	38.4	38.3	38.3	38.7	38.9	38.8	39.1	38.5	38.8	38.7	38.5	38.6b
Average	38.6	38.8	38.7	38.4	39.0	38.7	39.0	38.7	38.8	38.6x	38.8x	38.7
St. Joseph												
Normal	37.7	37.3	37.5	35.4	35.1	35.2	38.8	38.2	38.5	37.3	36.8	37.1a
Okra	36.6	36.6	34.4	34.4	34.5	34.4	37.8	37.0	37.4	36.2	35.8	36.0b
Super Okra	37.3	37.4	35.9	36.4	35.4	35.9	38.5	37.6	38.1	37.4	36.8	37.1a
Average	37.2	36.9	35.2	35.4	35.0	35.2	38.4	37.6	38.0	37.0x	36.5x	36.3
Average of Locations												
Normal	38.5	38.8	38.6	36.7	37.3	37.0	39.2	38.9	39.1	38.1	38.3	38.2a
Okra	37.4	37.2	37.3	36.4	36.5	36.4	38.0	37.5	37.8	37.2	37.1	37.2b
Super Okra	37.9	37.9	37.9	37.6	37.1	37.3	38.8	38.1	38.4	38.1	37.7	37.9c
Average	37.9	37.9	37.9	36.9	37.0	36.9	38.7	38.2	38.4	37.8x	37.7x	37.8

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y are used in rows.

not differ.

The row type x leaf shape interaction was not significant at either location or in the combined analysis, showing that the row type did not affect the behavior of leaf shapes.

Andries et al. (1969, 1970) reported that the okra and super okra leaf shapes had a higher lint percentage than their normal leaf isoline. This is in conflict with the findings of this study. But, Andries (1972) reported that Stoneville 7A (normal leaf) had a higher lint percentage than La. Super Okra-2 (super okra leaf) which in turn had a significantly higher lint percentage than La. Okra-2 (okra leaf). The latter study is in partial agreement with the results of this study.

Fiber Length (2.5% span length)

Mean 2.5% span length as affected by row types and leaf shapes for three years at two locations is presented in Table 27.

The mean 2.5% span length was 1.11 inches at Baton Rouge and 1.13 inches at St. Joseph, a statistically significant difference. Years and the interaction of years x locations were also significant.

Row types did not affect the 2.5% span length in any year at either location or as an average of locations.

Leaf shapes had highly significant effects on the 2.5%

Table 27. Mean 2.5% span length (inches) as affected by row type and leaf shape of upland cotton.

Location and Leaf Shape Genotypes	Years											
	1971			1972			1973			Average		
	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.
Baton Rouge												
Normal	1.12	1.12	1.12	1.10	1.10	1.10	1.12	1.14	1.13	1.11	1.12	1.12a*
Okra	1.11	1.10	1.10	1.09	1.09	1.09	1.11	1.13	1.12	1.10	1.11	1.10b
Super Okra	1.10	1.12	1.11	1.08	1.08	1.08	1.11	1.12	1.11	1.10	1.10	1.10b
Average	1.11	1.11	1.11	1.09	1.09	1.09	1.11	1.13	1.12	1.10x	1.11x	1.11
St. Joseph												
Normal	1.16	1.15	1.16	1.10	1.11	1.11	1.16	1.17	1.17	1.14	1.14	1.14a
Okra	1.15	1.16	1.16	1.08	1.08	1.08	1.15	1.16	1.16	1.13	1.13	1.13b
Super Okra	1.15	1.15	1.15	1.07	1.08	1.08	1.14	1.14	1.14	1.12	1.12	1.12c
Average	1.15	1.15	1.16	1.08	1.09	1.09	1.15	1.15	1.15	1.13x	1.13x	1.13
Average of Locations												
Normal	1.14	1.14	1.14	1.10	1.10	1.10	1.14	1.15	1.15	1.13	1.13	1.13a
Okra	1.13	1.12	1.13	1.08	1.09	1.08	1.13	1.15	1.14	1.11	1.12	1.12b
Super Okra	1.12	1.13	1.13	1.07	1.08	1.08	1.12	1.13	1.13	1.10	1.11	1.11c
Average	1.13	1.13	1.13	1.08	1.09	1.09	1.13	1.14	1.14	1.11x	1.12x	1.12

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y are used in rows.

span length. Normal had significantly longer fibers than okra which had again significantly longer fibers than super okra, as an average of locations. Similar results were obtained at St. Joseph. But at Baton Rouge, while okra and super okra had significantly shorter fibers than normal they did not differ from each other. Yet, the location x leaf shape interaction was not significant. Years x leaf shapes interaction was significant in the combined analysis but was relatively unimportant compared to main effects.

The row type x leaf shape interaction was not significant, indicating that the leaf shapes behaved similarly under the two row types.

Results obtained by Andries et al. (1969, 1970) and Andries (1972) on the effects of leaf shapes on fiber length substantiate the above results.

Fiber Length Uniformity Ratio

Mean fiber length uniformity ratio as affected by row types and leaf shapes for three years at two locations is presented in Table 28.

Significant differences were noted among locations and years for fiber length uniformity. The test averages were 43.9% at Baton Rouge and 45.1% at St. Joseph. The locations x years interaction was also significant.

Table 28. Mean fiber length uniformity ratio (%) as affected by row type and leaf shape of upland cotton.

Locations and Leaf Shape Genotypes	Years											
	1971			1972			1973			Average		
	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.
Baton Rouge												
Normal	43.8	44.4	44.1	44.6	44.5	44.6	45.3	45.2	45.3	44.6	44.7	44.6a*
Okra	43.3	42.3	42.8	43.6	43.7	43.7	45.1	45.9	45.5	44.0	44.0	44.0b
Super Okra	41.3	42.4	41.9	43.0	43.5	43.3	44.5	43.9	44.2	43.0	43.3	43.1c
Average	42.8	43.0	42.9	43.8	43.9	43.8	45.0	45.0	45.0	43.8x	44.0x	43.9
St. Joseph												
Normal	45.5	44.6	45.0	45.3	46.2	45.7	45.4	44.4	44.9	45.3	45.1	45.2a
Okra	45.9	45.1	45.5	45.4	46.6	46.0	45.2	44.2	44.7	45.5	45.3	45.4a
Super Okra	45.1	43.9	44.5	44.9	46.3	45.6	45.0	43.7	44.3	45.0	44.7	44.8a
Average	45.5x	44.5y	45.0	45.2y	46.3x	45.8	45.2x	44.1y	44.6	45.3x	45.0x	45.1
Average of Locations												
Normal	45.5	44.6	45.0	45.2	46.2	45.7	45.4	44.4	44.9	44.9	44.9	44.9a
Okra	45.9	45.1	45.5	45.4	46.6	46.0	45.2	44.2	44.7	44.7	44.6	44.7a
Super Okra	45.1	43.9	44.5	44.9	46.3	45.6	45.0	43.7	44.3	43.9	44.0	43.9b
Average	45.5	44.5	45.0	45.2	46.3	45.8	45.2	44.1	44.6	44.5x	44.5x	44.5

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y are used in rows.

Row type did not affect the fiber uniformity ratio at either location or in the combined analysis.

Leaf shapes had significant effects on fiber length uniformity ratio. Normal and okra leaf shapes did not differ significantly from each other, but, both had significantly higher fiber uniformity ratios than super okra leaf shape, as an average of years and locations. There was a significant location x leaf shape interaction, indicating that the leaf shapes behaved differently at the two locations.

The row type x leaf shape interaction was not significant, indicating that the leaf shapes behaved similarly under both the row types.

Fiber Strength

Mean fiber strength as affected by row types and leaf shapes for three years at two locations is presented in Table 29.

Significantly higher fiber strength values were obtained at St. Joseph (20.5) than at Baton Rouge (19.4), indicating a significant location effect. Locations x years interaction was also significant.

Row type did not affect the mean fiber strength in any year or location. This agrees with the findings of Hawkins and Peacock (1964).

Mean fiber strength was significantly affected by leaf

Table 29. Mean fiber strength (grams/tex) as affected by row type and leaf shape of upland cotton.

Locations and Leaf Shape Genotypes	Years											
	1971			1972			1973			Average		
	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.
Baton Rouge												
Normal	19.2	19.4	19.3	19.9	19.3	19.6	19.5	19.6	19.6	19.5	19.4	19.5a*
Okra	19.5	19.5	19.5	19.3	19.8	19.6	19.4	19.5	19.4	19.4	19.6	19.5a
Super Okra	19.0	19.5	19.3	19.3	19.5	19.4	19.2	19.2	19.2	19.1	19.4	19.3a
Average	19.2	19.5	19.4	19.5	19.5	19.5	19.5	19.4	19.4	19.4x	19.5x	19.4
St. Joseph												
Normal	21.5	21.4	21.4	20.3	20.8	20.5	20.3	21.3	20.8	20.6	21.1	20.9a
Okra	21.5	21.2	21.4	20.7	20.9	20.8	20.2	20.0	20.1	20.8	20.7	20.7a
Super Okra	20.7	20.6	20.7	20.4	20.5	20.4	19.0	18.9	19.0	20.0	20.0	20.0b
Average	21.2	21.1	21.1	20.5	20.7	20.6	19.8	20.1	19.9	20.5x	20.6x	20.5
Average of Locations												
Normal	20.2	20.3	20.3	20.1	20.1	20.1	19.9	20.5	20.2	20.1	20.3	20.2a
Okra	20.4	20.3	20.4	20.0	20.4	20.2	19.8	19.7	19.8	20.1	20.1	20.1a
Super Okra	19.8	20.0	19.9	19.8	20.0	19.9	19.1	19.1	19.1	19.6	19.7	19.6b
Average	20.1	20.2	20.2	20.0	20.1	20.0	19.6	19.8	19.7	19.9x	20.0x	20.0

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y are used in rows.

shapes at St. Joseph and as an average of locations, but not at Baton Rouge. Normal and okra leaf shapes had approximately the same fiber strength values, but, both were significantly higher than super okra. Significant location x leaf shape, year x leaf shape, and year x location x leaf shape interactions were observed. Andries et al. (1969, 1970) and Andries (1972) reported no significant differences among the three leaf shapes for fiber strength. Their results are in conflict with the findings of this study.

Micronaire

Mean micronaire values as affected by row types and leaf shapes for three years at two locations are presented in Table 30.

Mean micronaire values were not affected by locations, but years and years x locations interaction were highly significant.

Significantly higher micronaire values were obtained under skip-row planting than under solid planting at Baton Rouge and as an average of locations. The locations x row type interaction was not significant. However, the years x locations x row types was highly significant.

Leaf shapes had highly significant effects on micronaire values. As an average of locations, okra and super okra leaf shapes did not differ from each other, but, both were significantly lower in micronaire than normal leaf shape. The location x leaf

Table 30. Mean micronaire values as affected by row type and leaf shape of upland cotton.

Locations and Leaf Shape Genotypes	Years											
	1971			1972			1973			Average		
	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.	Solid	Skip	Avg.
Baton Rouge												
Normal	4.07	4.21	4.14a*	4.58	4.61	4.59a	4.37	4.33	4.35a	4.34	4.34	4.36a
Okra	3.38	3.74	3.56b	4.36	4.44	4.40b	4.16	4.32	4.24ab	3.96	4.17	4.07b
Super Okra	3.25	3.44	3.35c	4.13	4.41	4.27c	4.24	4.15	4.20b	3.87	4.00	3.94c
Average	3.56	3.80	3.68	4.35	4.49	4.42	4.26	4.26	4.26	4.06y	4.18x	4.12
St. Joseph												
Normal	4.08	3.72	3.90b	4.25	4.19	4.22a	4.02	4.25	4.13a	4.12	4.07	4.10a
Okra	4.01	3.83	3.92b	4.00	4.14	4.07a	4.08	4.22	4.15a	4.03	4.08	4.05a
Super Okra	4.23	4.09	4.16a	4.08	4.27	4.18a	4.03	4.11	4.07a	4.11	4.16	4.13a
Average	4.11x	3.88y	3.99	4.11x	4.20x	4.16	4.04x	4.19x	4.12	4.09x	4.10x	4.09
Average of Locations												
Normal	4.07	3.99	4.03	4.41	4.40	4.41	4.19	4.29	4.24	4.23	4.23	4.23a
Okra	3.66	3.78	3.72	4.18	4.29	4.24	4.12	4.27	4.19	4.00	4.12	4.06b
Super Okra	3.70	3.74	3.72	4.10	4.34	4.22	4.14	4.13	4.13	4.00y	4.08x	4.03b
Average	3.81	3.83	3.82	4.23	4.34	4.29	4.15	4.22	4.19	4.07	4.14	4.11

* Means followed by a letter in common do not differ at the 5% level of probability. The letters a, b, c are used in columns and x, y are used in rows.

shape, year x leaf shape and location x year x leaf shape interactions were significant, indicating an important differential effect on micronaire by the three leaf shapes.

There was no significant interaction between row types and leaf shapes, indicating that the row types did not affect the leaf shapes for micronaire.

SUMMARY AND CONCLUSIONS

Tests were conducted in 1971, 1972 and 1973 at Baton Rouge and St. Joseph, La., with three leaf shapes of upland cotton in solid and skip-row (2 x 1) plantings in a split-plot design. 'Stoneville 7A' cultivar (normal leaf), La. Okra-2 (okra leaf), La. Super Okra-2 (super okra leaf) and no canopy (open ground) represented the different canopy treatments. The three genotypes were considered to be near isogenic strains and therefore differences among them were attributed primarily to differences in leaf shape and area. Plant microclimate (soil surface temperature, light penetration and relative humidity) and boll weevil survival were studied at Baton Rouge only, while boll rot and other important agronomic characters were studied at both locations.

In 1971, only daily maximum soil surface temperature was recorded. In 1972 and 1973, soil surface temperatures were expressed as daily maximum temperature as well as total degree-hours above 85, 90 and 95 F. Super okra almost always registered higher mean daily maximum temperature and higher total degree-hours above 85, 90 and 95 F than okra which again generally registered higher mean daily maximum temperature and total degree-hours than normal leaf. The no canopy treatment always had much higher temperature values than super okra. In 1971, the effects of skip-row planting and the side of the row (east or west) were also studied. It was found that the soil surface temperatures under plant canopies were not appreciably affected by row type. Soil surface temperatures were somewhat higher on the west side of the row than on the east side in mid-July but had little effect when plants became large. The average maximum soil surface temperature (mean of three years) under super okra and okra leaf canopies were about 6.6 and 2.5 F higher, respectively, than under normal leaf canopy. Super okra and okra leaf canopies had 8.6 and 3.3 times more degree-hours above 85 F, 20 and 6 times more degree-hours above 90 F, and 28 and 7 times more degree-hours above 95 F, respectively, than normal leaf canopy, as an average of 1972 and 1973. The no canopy treatment accumulated an average of 1688 degree-hours above 85 F, 1245 degree-hours above 90 F and 876 degree-hours above 95 F.

Amount of sunlight penetration in foot-candles was measured at the soil surface level under the three leaf shape canopies during bright sunshiny hours. More sunlight penetrated through the super okra leaf canopy than okra and normal leaf canopies. As an average of two years (weighted average), the amount of sunlight incident at soil surface level for the no canopy treatment was 6330 foot-candles. It was interesting to note that only 2.4, 5.0 and 8.5% of the total sunlight penetrated the normal, okra and super okra leaf canopies, respectively.

Relative humidity (RH) was expressed in absolute values in 1971 and as durations of RH above 95% or above in hours per day in 1972 and 1973. In 1971, the results indicated that the RH values in super okra and okra leaf canopies were lower than that in normal leaf canopy. The differences between super okra and normal leaf shapes were much larger than those between okra and normal leaf shapes. It was also observed that the RH values in skip-row were slightly lower than in solid-row. The RH values at 24-inch level in plant canopies were slightly lower than those at 12-inch level and the 12-inch level values were lower than those at soil surface level. As an average of 1972 and 1973 data, it was found that the super okra and okra leaf canopies had shorter durations of 95% or above RH than normal leaf canopy at a height of 4 to 12 inches above the soil surface. The duration of RH of 95% or above was 14.1 hours per day in normal leaf canopy which was 18 and 48 minutes longer than those under okra and super okra leaf canopies, respectively.

Percent weevil survival was determined from field-exposed boll weevil oviposited squares under the three leaf shape canopies and no canopy treatment. The effect of solid and skip-row types was also studied in 1971. It was observed that the row type did not have appreciable effect on weevil survival. But the side of row (east or west) seemed to have a small effect, especially on solid row plots, and this may have been due to the angle of incidence of sunlight. Leaf shape did affect weevil survival. As expected, the weevil survival under no canopy (average of 1972 and 1973) was the lowest (10.3%). Among leaf shapes, super okra had the lowest percentage of weevil survival. Okra leaf canopy had higher weevil survival than super okra leaf but lower than normal leaf. In 1971, super okra and okra leaf canopies reduced the weevil survival, on an average, by 12 and 5%, respectively, over normal leaf canopy. In 1972, as an average of nine batches, super okra and okra leaf canopies resulted in an average reduction of 16.7 and 9.4% in weevil survival, respectively, over normal leaf canopy. In 1973, the super okra and okra leaf canopies caused an average reduction of 4.1 and 0.4% in weevil survival over normal leaf canopy, respectively. Overall boll weevil survival under the three leaf canopies was appreciably lower in 1972 (56%) than in 1973 (67%). A count of actual dead (identified) weevils under the four canopies also indicated that the greatest number of dead weevils were found under no canopy treatment followed by super okra, okra and normal leaf canopies, substantiating the results reported earlier.

The relationship between soil surface temperatures and boll weevil survival was also studied. Covariance studies indicated a moderately strong negative correlation between these two variables. It was found that the temperatures during first week of the 2-week exposure period contributed most towards the total boll weevil mortlity. The degree-hours above 85 F during the first week and the degree-hours above 90 F during the second week, together, had the highest R^2 square value. A regression equation (linear) involving these two variables was fitted for predicting weevil survival.

Boll rot losses (lint cotton, lb/acre) were significantly affected by row types and leaf shapes. Skip-rows had higher boll rot losses than solid-rows, but as a percentage of total crop, skip-row lost less lint cotton than solid-row due to boll rot. Super okra and okra leaf shapes caused a reduction of 38.2 and 15.9% in boll rot losses over normal leaf, respectively.

Skip-row planting also resulted in taller plants, 40% higher lint yield and heavier bolls than solid planting. Solid-row was earlier in maturing than skip-row. The percentage of total crop harvested at first picking was 53.6 in solid planting compared to 49.4 in skip-row planting. While the row type did not affect lint percentage, 2.5% span length, length uniformity ratio and fiber strength, skip-rows had higher micronaire values than solid-rows.

Leaf shapes significantly affected all the agronomic characters studied. Okra leaf plants were taller than normal leaf plants which were again taller than super okra leaf plants.

Normal leaf shape yielded significantly more lint than okra and super okra leaf shapes, as an average of row types, years and locations. But okra and super okra leaf shapes did not differ significantly from each other.

Greater percentage of total crop was harvested at first picking in super okra plots (65.9) than in okra (49.3) and normal leaf (39.2) plots. If the first picking was delayed until approximately 70% of the crop was open, super okra plots could have been harvested an average of 5.3 and 11 days earlier than okra and normal leaf plots. Okra leaf plots could have been harvested an average of six days earlier than normal leaf plots.

Normal leaf was higher than okra leaf and okra leaf was higher than super okra leaf in average boll weight, lint percentage and 2.5% span length. Normal and okra leaf shapes did not differ from each other but both had higher fiber length uniformity ratios and fiber strength values than super okra. The location x leaf shape interaction was significant for both characters. Okra and super okra did not differ from each other in micronaire but both were significantly lower than normal leaf. The location x leaf shape interaction was again significant for this character.

The row type x leaf shape interaction was significant in the combined analysis for lint yield but not for any of the other agronomic characters studied. Under solid-row planting, normal leaf yielded higher than okra leaf. Normal and super okra or okra and super okra did not differ from each other. However, under skip-row planting, normal leaf yielded higher than okra leaf and okra leaf yielded higher than super okra leaf. It indicates that super okra leaf shape could not compensate in yield as well as normal or okra leaf shapes for wider row spacings.

It was concluded that the okra and super okra leaf shapes may be of some value in suppressing a build-up of boll weevil population and in reducing boll rot losses. Perhaps, these advantages attributed to okra and super okra leaf shapes may be realized even more under a drier climate than that at Baton Rouge.

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VITA

Puppala Subhash Chandra Reddy was born in Hyderabad, India, June 6, 1947. He graduated with a first class diploma from Methodist Boys' Multipurpose High School, Hyderabad, India, in June 1963.

He obtained his B.Sc.(Agri.) degree in June 1967, and M.Sc.(Agri.) degree in Agronomy in January 1970, in first class, from Andhra Pradesh Agricultural University, Hyderabad, India. He was awarded a state merit scholarship for undergraduate studies, and junior research fellowship by the Indian Council of Agricultural Research for graduate studies. He was twice selected, during his undergraduate studies, as editor of the semi-technical journal "Krishik" (Farmer), published annually by the College of Agriculture, Hyderabad, India. Later, as a graduate student, he was elected as President of the students' union.

He worked from May to September 1970, as an instructor in the Department of Agronomy, College of Agriculture, Hyderabad, India.

He joined the Department of Agronomy, Louisiana State University, Baton Rouge, La., in September 1970 for his doctoral degree. He has been a graduate research assistant in cotton since June 1971, assisting in various cotton research projects.

He also served as President of the Indian Students' Association of Louisiana State University, Baton Rouge. He is a member of Gamma Sigma Delta Honor Society, American Society of Agronomy and Crop Science Society of America. He is now a candidate for the degree of Doctor of Philosophy in the Department of Agronomy.

EXAMINATION AND THESIS REPORT

Candidate: Puppala Subhash Chandra Reddy

Major Field: Agronomy

Title of Thesis: Effects of Three Leaf Shape Genotypes of _Gossypium hirsutum_ L. and Row Types on Plant Microclimate, Boll Weevil Survival, Boll Rot and Important Agronomic Characters.

Approved:

Jack E. Jones
Major Professor and Chairman

James G. Traynham
Dean of the Graduate School

EXAMINING COMMITTEE:

R. Larry Rogers

K. W. Tipton

W. H. Willis

E. P. Dunigan

M. T. Henderson

Dan F. Clower

Date of Examination: November 18, 1974